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AGRICULTURAL ENGINEERING

The Journal of the American Society of Agricultural Engineers

FEBRUARY 1930

Present Trends in Large-Scale Wheat Production - - - - - - - - *Hickman Price*

Some Experiences in Industrialized Farming - - - - - - - - - - - *John S. Bird*

Factors Determining the Capacity of Field Machines - - - - *E. G. McKibben*

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California Rice Land Seeded with an Airplane - - - - - - - - - - *E. N. Bates*

Standardization of the Power Take-Off for Tractors - - - - - - - - - *W. L. Zink*

VOL. 11 NO. 2

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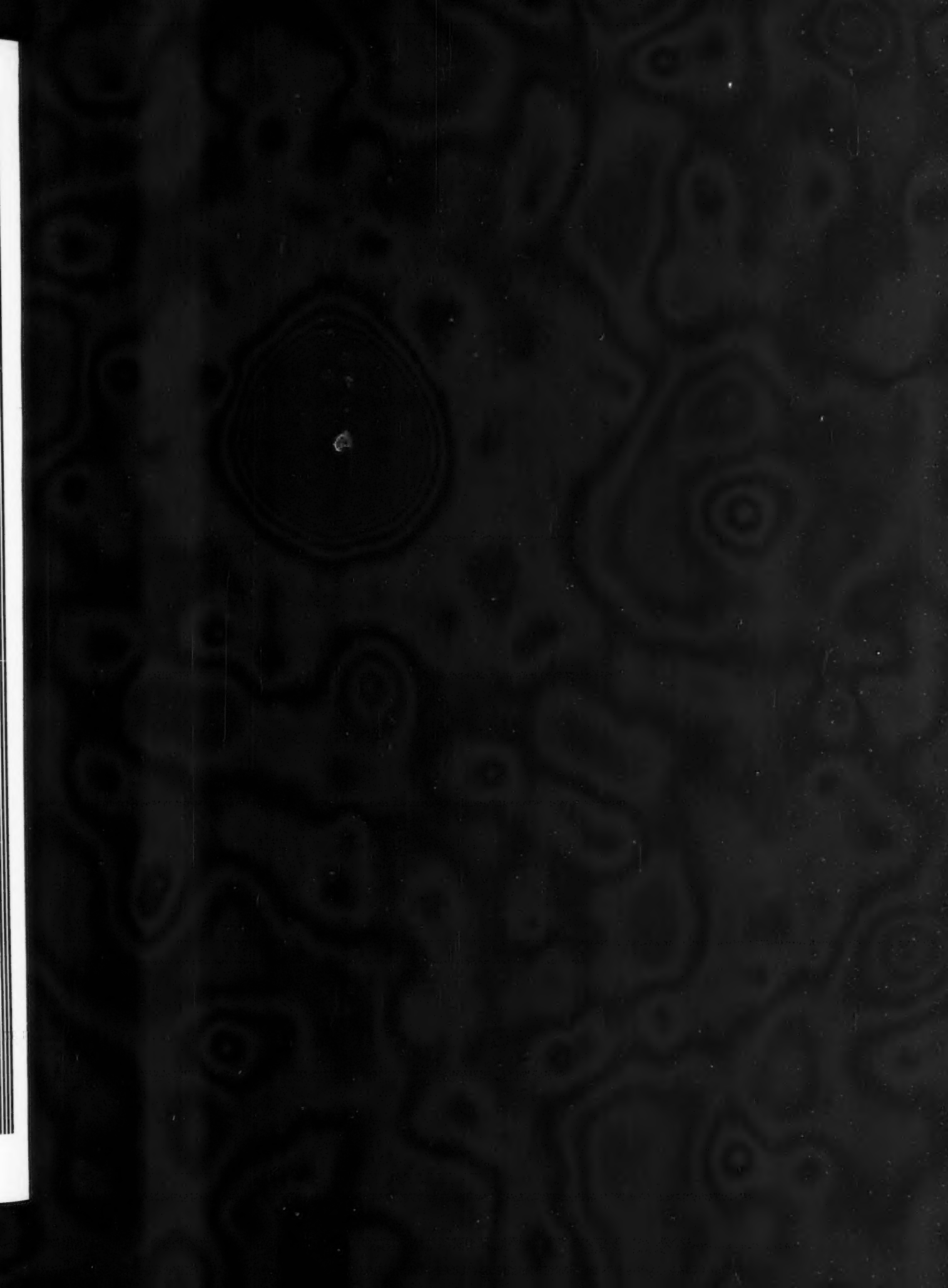

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AGRICULTURAL ENGINEERING

Vol. 11 FEBRUARY, 1930 No. 2

Trends in Large-Scale Wheat Farming[1]

By Hickman Price[2]

NEW-ERA, mechanized agriculture offers unusual opportunities for service and attractive financial rewards. Agriculture is the only large industry not yet modernized. Hence, its phenominal possibilities as it develops along new lines.

Small grain farmers are profitably expanding their operations out of profits in northwest Texas, where power machine methods are especially applicable. For example, ten years ago, a man of fifty started with five hundred acres. From earnings, through purchase or lease, his acreage increased to eleven hundred, sixteen hundred, twenty-two hundred, twenty-eight hundred and this year to four thousand. Year before last, three brothers, small town merchants, decided to try their hand at wheat farming. They leased six thousand acres of sod land, plowed it up and put it into wheat. The machinery and crop cost them $100,000. They sold it for $185,000 with a net cash profit of $85,000.

Here is the basis upon which large-scale wheat production is computed in northwest Texas: Ten-year average per acre yield, 12 bushels; price $1.00 per bushel, $12.00; cost per acre, $6.00 to $8.00; net profit per acre, $4.00 to $6.00. Improved soil management should increase the average yield. With modern methods a 15-bushel per acre yield, depending upon market price, should net from $3.00 to $6.00.

Thanks to progressive tractor and machinery manufacturers, farm methods in northwest Texas have improved greatly in recent years. Bumper crop yields of wheat and other small grains have frequently paid in one year for the cost of $25.00 to $45.00-per-acre land.

Large areas of excellent land awaiting development have made expansion of wheat acreage comparatively easy. Much of the panhandles of Texas and Oklahoma, eastern New Mexico and Colorado, western Kansas and other areas in the Great Plains region offer ample opportunity for this type of farming. Wheat acreage is extending rapidly. Last spring one-quarter million acres changed hands in Baca County, Colorado, preparatory to wheat production. One hundred fifty thousand acres of sod land in Moore County, Texas, have been put into wheat this year. Quay County, New Mexico, has increased its 1930 wheat acreage by 100,000 acres.

Wheat acreage in northwest Texas now totalling two and one-half million, may be increased to eight or nine million. This is part of fifteen million acres in the 26 Texas panhandle counties, much of which is devoted to corn, cotton, maize, kaffir and other crops. The Texas panhandle is the size of the state of Pennsylvania.

Millions of unplowed acres in the southwest are admirably suited to wheat production. How much will be put into cultivation depends upon how long thousands of farmers, business and professional men, eager for profits, will continue to rush into wheat farming. The trend of market prices will determine this. Overproduction will lower prices. A price of 50 cents per bushel to farmers is a possibility.

With a 42 per cent increase in acreage and the crop in excellent condition, the 1930 Texas panhandle wheat crop may exceed 50,000,000 bushels.

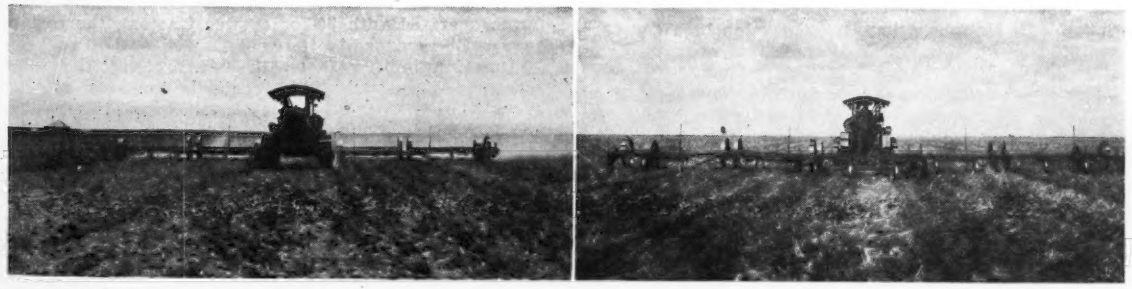
Here is the five-year wheat record of northwest Texas:

1925—1,000,000	acres	8,000,000	bushels
1926—1,100,000	"	22,000,000	"
1927—1,500,000	"	14,000,000	"
1928—1,750,000	"	22,000,000	"
1929—1,750,000	"	42,000,000	"
1930—2,500,000	" (estimated)	55,000,000	"

Agriculture's embarrassing position comes from stress and strain of adjustment to the new order. Its growth and prosperity came in the horse and mule era. In this, the motorized power age, it has been uncomfortably out of step. Prophets of the new-day agriculture, like M. L. Wilson, Thomas D. Campbell and John S. Bird, have demonstrated that large-scale farming of necessity must in large measure, in the Great Plains region at least, replace 160, 320 and 640-acre farms.

It was in December, 1927, that W. E. Grimes, professor of agricultural economics at Kansas State Agricultural College, declared "The size of combines and tractors now commonly used in this region (the wheat area of the Southwest) requires farms of one thousand to four thousand acres to permit their efficient utilization. This is two to four times as large an area as is included in the present usual farm of the area."

This means that acreage now comprising 165,000 farms



Front and rear views of one of Mr. Price's 60-hp. tractors pulling a 50-foot rod weeder in high speed, covering 400 acres in a 22-hour day

[1]Paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, Chicago, December 1929.

[2]Large-scale Texas wheat farmer. Mem. A.S.A.E.

in Kansas could be more efficiently operated if their number were reduced to about 40,000. This would eliminate 125,000 farms. Drastic as it may appear, such a reduction might not prove as far reaching in its effects as have numerous commercial and industrial shifts.

How surprised must have been stockholders in companies operating stage coaches and sailing ships to find their shares worthless, because steam power applied to overland and oversea transportation had supplanted the less adequate means of travel.

Recently William I. Austin, chief statistician of the agricultural divison of the U. S. Census Bureau, declared the decennial census would plainly show the continued decline in farmer's ranks, due, among other things, to the use of modern machinery.

When George Washington cultivated his beloved acres at Mount Vernon, ninety per cent of the nation's population was identified with agriculture. As farm workers are given constantly increasing power, and fewer man-hours are necessary to produce farm products, the present farming population of 25 per cent will shrink possibly to 10 per cent or less.

What will become of the millions of farm workers thus affected? What became of farmers as our agrarian population dwindled from ninety to twenty-five per cent? By engaging in other occupations they increased their usefulness, steadily raising their living standards.

In step with this fast-moving age, the drop in farm population from twenty-five to ten per cent is likely to occur more rapidly than heretofore. Swift adjustment occasioned by numerous farmers leaving rural districts to improve their economic status need not be accompanied by fear of the outcome. Today's demand for manufactured goods and services, both in variety and quantity, vastly exceeds anything previously known. Farmers without much wasted time or effort will obtain remunerative and satisfactory connections in other lines. Pressure of economic law pinches. Usually this benefits those whose discomfiture, for awhile, is greatest. It takes them out of useless, rutty places. It puts them where their activities become more purposeful, resultful and pleasant.

The engineer sees agriculture approaching a second crisis. The first came when small farmers began to use power machinery instead of horses, mules and human muscle. This decade is seeing this movement's climax. It manifests itself in a tremendous reduction of man-power on the farm, and in the gradual elimination of the old style farmer who cannot compete with the small power farmer. This stage of the revolution has given the small farmer in machine farming the power of ten to twenty horses, all manageable by one man.

The second crisis, just beginning, develops out of competition between the new mechanized small farmer and the superfarming engineer.

Quite naturally, designing of farm machinery thus far has been based upon the assumption that most farmers will continue to operate only a few hundred acres. The entire design of farm machinery as well as the commercial policy of machinery manufacturers are based, and for some time to come must continue to be based, on this assumption. However, there must develop here and there genuine superfarming which discards this assumption and makes a wholly new one.

The new assumption is that scientific farming has one goal, that of producing foodstuffs and other commercial products as cheaply as possible and without injury to farm workers. The old method of getting cheap food was through exploited or underpaid labor. The producer has been made to suffer for the sake of the consumer. This was unjust. The new ideal is to be equally fair to producers and consumers, while reducing selling prices to a minimum. This ideal can be attained as low-cost production and increased efficiency are secured through use of superpower tractors with accompanying properly designed machinery.

Engineer-farmers are most likely to succeed if they analyze their problems in much the same terms as large-scale contractors. The primary task of new-era farming is that of speedily handling enormous masses of earth. The essential aim is to do this as cheaply as possible.

In his new, thought-provoking book, "Too Many Farmers," Wheeler McMillen[3] asks the pertinent and timely question, "Wherein lies the superior productive ability of the American farmer?"

"Mostly in his use of power and machinery," declares McMillen.

Continuing, he says, "Power and power machinery are not efficiently used unless employed for as long a time and over as large an area as possible. The interest and depreciation for full power equipment on a small tract would more than cancel the saving in man labor per acre. The average Iowa tractor works 200 hours a year. Tom Campbell[4] runs his tractors 2,000 hours a year. The large farm unit is destined to have the greater economy in cost."

Because of ideal climatic and soil conditions in northwest Texas, our tractors run almost continuously night and day throughout the year. As there is always work ahead they stop only for servicing or when the ground is frozen or too wet. We produce other small grains in addition to wheat. We plow sod of new acreage acquired from time to time. We break sod in the winter and spring for others under contract. Therefore, our tractors operate from 5,000 to 6,000 hours a year. In intermediate gear, at about three miles an hour on most of the jobs, each tractor travels approximately 18,000 miles annually. Idle machinery yields no investment return. Hence, we have contracted to break about 25,000 acres of sod land for others this winter and spring. This aids us in keeping competent, year-around men. It furthers our policy of building up an everexpanding organization.

In our farm work in northwest Texas during 1930 we will move approximately one hundred million tons of soil. To develop the drawbar horsepower necessary to move this mountain of earth, we anticipate burning upwards of a quarter of a million gallons of gasoline. We will use about six thousand gallons of lubricating oil. It means the consumption of one thousand gallons of transmission oil and thirty-eight thousand pounds of grease.

In the interests of increased farming efficiency, resulting from greater tractor fuel economy, we are hopeful that assistance will come to the large-scale users of petroleum products to the end that crude oil or other tractor fuels can be used, thus making it possible to cover three or four times the acreage at the same expense. Few engineering problems deserve closer scrutiny.

Our recent studies of wheat cost of production show that merely by using standard tractor power double that of the largest commonly used farm tractor, and by operating on a factory basis of continuous operation, the cost of growing wheat can be slashed far below the cost obtainable by the small farmer.

Recent valuable contributions to this subject by M. L. Wilson[5] in Montana show that on 800 to 1400-acre farms operated with 30-horsepower tractors, the cost per acre can be reduced to $8.70.

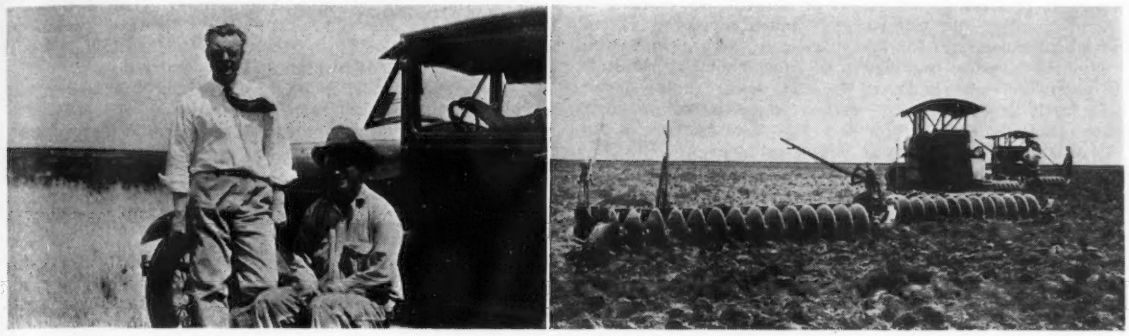
Our tests indicate that with 60-horsepower tractors and correspondingly larger implements the cost can be cut to about $6.00. We believe that larger types of machinery and larger unit acreages will result in greater reductions in production cost.

We hope the time is near when manufacturers aided by agricultural engineers will make it possible to farm ever larger acreages, at constantly lowering costs, through

[3]Associate editor, "Farm and Fireside." Aff. Mem. A.S.A.E.

[4]Thomas D. Campbell, president, Campbell Farming Corp. Mem. A.S.A.E.

[5]M. L. Wilson, professor and head of the department of agricultural economics, University of Montana.



(Left) Hickman Price (standing) in the field. (Right) Sixty-horsepower Caterpillar tractors each pulling two 10-foot disk plows on the Hickman Price farm at Kress, Texas

the use of superpower machinery with tractors of, say, 500, 800, or 1000 horsepower.

As regards farm engine power, the field of the unknown is so vast no one dare say what is impossible. Compare the modern 4,500 horsepower locomotive to the stage coach drawn by four horses; the steamship Bremen with the Mayflower; the compressed air drill, the steam shovel, the drag line shovel, with the untold human energy they save.

One objection to superfarming has been that as the capital for it increases, so do the hazards. The answer to this has been found by such concerns as the United Fruit Company. It distributes its vast acreage over large areas. Hail risks and effects of vagaries of the weather and pests are correspondingly distributed.

With the seasons varying from year to year, the surest, airtight defense against unfavorable weather conditions—the proverbial bugaboo of farming—is had in an ample supply of power and equipment. With machinery sufficient to cover the entire acreage in a short time, it is possible to avail one's self to the utmost of the all-important element of timeliness, making or saving crops otherwise lost. Thus in large measure, modern, mechanized agriculture effectively combats that which, up to now, has been the bane of farming—the omnipresent weather hazard.

Thus far no human has been able to control the time or extent of precipitation or temperatures. The nearest approach to this is had in the protection which comes through being mechanically equipped to perform the work speedily and thoroughly when weather conditions permit. Such times by reason of availability of sufficient power usually prove to be opportune.

Our farming operations, chiefly upon land owned by ourselves, cover about 30,000 acres. This embraces four tracts in four counties in northwest Texas. The acreages of these respective tracts are 4480, 7080, 8640 and 9600. It is seven miles between the two closest farms and 120 miles between the two that are farthest apart.

What is the proper size of an economic farm unit? No one can answer this question. For no one knows the potential capacity of tractors or implements yet to be developed. In the Great Plains region we anticipate that the size of units will increase as rapidly as larger power plants and tools become available. It has already been demonstrated that the larger they become, the lower is the production cost.

Formerly it was regarded as good business to use farm machinery as long as possible. No sooner do we purchase the latest and best equipment than we eagerly and aggressively search for new time and labor-saving methods and machinery. As they become available the older equipment and practices are discarded. Within the month we have abandoned three up to now fundamental procedures, as newer, better ways have proven the former ones wasteful. This scrapping policy is carried out as rapidly as it is demonstrated that savings can be effected. There is nothing original in this. It is simply capitalizing upon the general practice employed in all modernly conducted businesses.

Farming does not have to blaze a trail to economic freedom. The way has already been opened by other industries, through modern management, accounting, specialization, standardization and mass production.

If there is one thing agriculture can learn from industry, and surely there is a great deal, it is the certainty the twentieth century ushered in the passing of the individual producer. Only through large-scale, collective, group, specialized, departmentalized activity has modern prosperity, with the accompanying high standards of living, become possible.

The best interests of the American public, in the opinion of Henry Ford, would be served if all electricity consumed in the United States were supplied by one giant corporation. By the same token, it is more than likely that this industrialist would declare for the public benefits gained through one organization producing all the wheat in the United States. Of course such a development may never occur. Yet it offers something to think about.

Ford and Chevrolet manufacture half of the entire output of American automobiles. If one farmer grew a million bushels of wheat, he would produce only about one per cent of this country's crop. However, this one per cent probably would be manufactured upon an economical basis. Hence these operations would be of greater value than those of the average farmer, to the economic and social fabric in which everyone has a part. The best interests of these United States, which in large measure depend upon successful agriculture, will be served through encouragement of every legitimate step in the direction of larger-scale, superpower farming.

Men of unusual intelligence and energy will devote themselves to super-farming, in preference to overcrowded banking, manufacture, building, transportation and commerce. Through these men and others, agriculture will draw upon the accumulated experience of many fields of endeavor. Productive efficiency will be greatly increased. Farming will gather an unbelievable momentum and be established upon a much more substantial basis than at present.

As agriculture develops within its ranks executives of vision and draws others from afar, there will develop the multiple-unit idea of operation which has contributed so greatly to the modernization of merchandizing, industry and banking. The day is approaching when a farm executive at his desk will telephone as often as desirable to his assistants operating large acreages in different states. He will know first-hand the conditions on the different units, for his airplane will aid him in making observations swiftly and easily.

The small one-man farm was efficient in labor utilization. It was suited to the time when labor was the most

important production factor. It is distressingly inefficient in, and unsuited for, utilization of machine power, capital and management and for labor division and specialization.

Modern farming is a battle of equipment. Agriculture will make increasingly heavy demands upon tractor power. Henceforth super-power is the key to successful farming. Brute force and flexibility of power of farm tractors in due course will be something at which to marvel. The first ones will be probably come into being when some successful large-scale farmer, able and willing to pay the price, asks for manufacturer's bids to build what he has in mind.

Regular internal-combustion, Diesel or other type engines are changing the whole aspect of farming from the standpoint both of crop production and transportation. The new units because of their wider range, higher speed, load capacity and economy, will perform hourly feats which might now appear visionary. They will shrink a 1000 acre field to the size of a ten-acre lot.

Thomas Edison declared recently that we only know one millionth of what there is to know. As our horizon broadens heretofore insurmountable obstacles vanish. The agricultural millenium is not far around the corner, when the truth becomes more generally recognized. There is no limitation which can not be met. Then will be ushered in the new era, thanks to agricultural engineering, when millions of men, yes, and women too, will be freed from the slavery of wasteful muscle toil.

Greatly increased mechanization and efficiency of farming, obviously enough, will result in a serious surplus situation created by vast overproduction. As calamitous as this first appears, it will in time prove best for the nation's good. Surplus difficulties will effectively enforce adoption of new farming practices.

Farm prices are now set by production costs of inefficient operators. Incentive for adopting the new farm system has been comparatively small as inefficient producers are still satisfied with poor living standards. A fall in farm commodity prices would coerce inefficient producers to adjust themselves to efficient production. Or it would cause them to find more satisfactory means of livelihood. Such a drop in value of farm products would be a blessing in disguise. Temporarily it would place infinite hardships on indifferent farmers. Their income for the time being probably completely disappear. This would force everyone desiring to remain in agriculture to adjust themselves to the new order, thereby making it general. The benefit to the country as a whole would come from savings made through low cost production methods. Ultimately such a fall in farm product prices will occur. In the end all prices adjust themselves to improvement in production methods.

We are bending our energies to getting wheat production upon a cost basis which will enable us to sell it with substantial profit at fifty cents a bushel. We believe, if for the most part, constant, intelligent, attention is given to evolving even better low cost production methods, that distribution and marketing problems will adjust themselves.

The time has come for agriculture to be recognized for just what it is—the greatest of all public utilities. It is the one basic public utility furnishing food, clothing and shelter. As with all other public utilities the essential factor is that of developing constantly lowering production costs. If skill is employed in this, questions of surplus will adjust themselves automatically, as newer and wider uses for farm products are uncovered and developed.

The change now under way in farming means a complete transformation of the agricultural industry. This process will be accompanied by far greater reactions than the change of certain production methods. Agriculture's present evolution is to be compared with the change in manufacture during those decades when the industrial revolution was at its height.

The crisis through which agriculture is now progressing will be further intensified by its being condensed into a comparatively short time. The industrial revolution continued decades. Its good and evil effects were spread over an extended period. The agricultural readjustment, however, promises to proceed rapidly. With everything now moving more speedily, it is likely that once well under way, it will work itself out in a few years.

Speaking for the moment only about wheat farming, we call attention to the fears of many wheat growers that within a few short years the enormous expansion of wheat growing in Russia may put an end to the American wheat grower's prosperity. We believe this will happen only in the event Americans fail to advance in the next stage of development, and regard wheat farming as an engineering proposition.

A widely read editorial writer wrote the other day, "What chance have we, the little man, individual storekeepers ask, reading that forty-eight chain stores in October took in more than $249,000,000, or about $50,000,000 more than in last October.

"The crowding out process is not new. One locomotive engineer does the work of 1,000 stage coach drivers. Yet, comparatively well-paid engineers are more numerous than coach drivers were.

"Business more highly organized, selling for less, making more profit, by efficient distribution, will give more and better opportunities to the small merchant. The period of transition will be painful, but there is no use in fighting the stream. Go with it."

May we not, in agriculture, advantageously follow this sage counsel?

These remarks have been concerned largely with the application of power to agriculture, But whence comes real power? The wisest of all men, Jesus Christ, declared that power comes from God, and that it is omnipotent. He said God is everywhere, in every selfless thought and good deed. He emphasized that man expresses God, and reflects His power to the extent that he faithfully and understandingly obeys His laws and practices the rule which the Master called golden.

Wisdom once voiced itself in these words, "Unless the Lord build the house, they labor in vain that build it."

There is no telling how fruitful and wonderful agriculture will become, when man steps aside to observe the majesty and power of God and permits God to work through him. There is no agricultural problem which man cannot solve if he is conscious of his at-one ment with his Creator and if in his heart there is ever the true spirit of Thanksgiving and Christmas.

Truly it is a rare privilege to live, work and serve in this marvelous age.

Moderately Deep Plowing for Corn Borer Control

RECENT tests by agricultural engineers of the Bureau of Public Roads, U. S. Department of Agriculture, indicate that infested cornstalk land should be plowed at least six inches deep to cover stalks well enough for corn borer control. Seven-inch and eight-inch plowing resulted in cleaner work than six-inch, where subsoil conditions permitted the extra depth, but a depth of ten inches was little or no more effective than eight inches.

Plowing at proper depth is an important factor in covering trash competely, but does not insure good results under poor soil conditions or when inefficient plows are used. For best results the plow should have plenty of clearance between the bottoms and be equipped with rolling coulters, jointers and covering wires, or equivalent attachments. At least a fourteen-inch plow bottom should be used, and it should be shaped to make wide, open furrows and to turn the soil smoothly and completely.

Proper adjustment of all plow parts and careful operation in the field are required to secure the complete coverage of trash necessary for corn borer control.

Some Experiences in Industrialized Farming[1]

By J. S. Bird[2]

RUSSELL SAGE is credited with the statement, "When everyone else stands up is a good time for you to sit down." When every organized political and farm organization, in fact when the question of farm relief was discussed to the limit, everybody seemed to be "standing up" so far as farm problems were concerned.

It was at this time that it occurred to the men of our organization that the question of cheapening farm production was receiving too little attention; that the mechanization of agriculture was only in its beginning and that through the application of power, mass production, and business management, probably more could be done to assist agriculture in its larger phases than through almost any other means. Therefore, The Wheat Farming Company was organized to enter upon the production of farm crops for profit through the ownership of large tracts of level, fertile, prairie lands, adapted to the production was receiving too little attention; that the me- in large acreages. It is the policy of The Wheat Farming Company to own this level land; to operate it with the most efficient modern, mechanical equipment; to operate by the most productive methods yet discovered by the government, by the state experimental agencies, or the most successful private producers in this country; and to manage this business as the most efficient industrial businesses are managed.

The selection of the section in which to operate was, of course, a question. Soil, climate, labor conditions, price and topography of lands were all to be taken into account in this matter. If one will consult Miscellaneous Circular No. 81 of the U. S. Department of Agriculture, it will be found that as many things are in favor of the Nebraska-Kansas region of the Great Plains region as any. The Wheat Farming Company operates in ten counties of Kansas, the southeast corner one being Ellis County in which is one of the largest agricultural experiment stations in the world—the Fort Hays Station. Five counties to the west takes one to the state line, and another tier of five counties lying north of these first five makes up the company's present field of operation. There are many reasons in favor of an east and west distribution of territory: It minimizes hail and weather risk and gives a variation of altitude.

Organization and Operation. The Wheat Farming Company owns its land and equipment, providing capital of the same by the sale of common stock to the amount of 150,000 shares, the first 100,000 shares being sold at $20.00 the next 50,000 to be sold at $25.00 or more per share. All of this stock is of no par value. In addition, preferred stock to the amount of 3,000 shares, each of $100.00 par value, have been offered, and practically all subscribed. This is 7 per cent cumulative preferred as to dividends and principal.

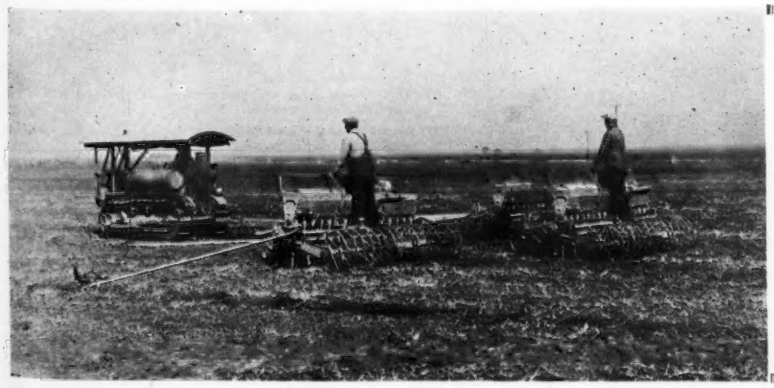
The capital raising, the publicity, and the educational department is maintained at Topeka, Kansas, as a matter of business convenience. The publicity has been educational in character presenting the more basic facts concerning agriculture, agricultural production and agricultural management. In short, it may be said that the capital-raising problem has been solved very satisfactorily from the beginning.

Production and Equipment. In order to get production, there must be land and equipment with which to operate the land. A great change has been taking place in agriculture during the last fifteen years, especially since the beginning of the World War; a change which means larger investment for equipment that provides for the use of much power—mechanical power—and the smallest possible use of man power. The former has become cheaper and the latter more expensive. Selection of the right kind of machinery in proper sized units was and is a problem. It may be said in passing that American manufacturers of farm power, tillage and harvesting machinery have made such satisfactory progress that there are several lines of fine equipment from which to choose. Yet much remains for the engineer and designer of farm machinery. One cannot take them all. In the interest of efficiency and good business management there must be uniformity of equipment so that interchange of the same may be made from unit to unit. In our own set-up, units of 5,000 or 10,000 acres are the objectives for which the company is striving. By uniformity of equipment much unnecessary duplication may be obviated.

Proper care and preservation of expensive equipment was a problem and still is. For this purpose was organized an equipment-maintenance division with shop, repair and manufacturing machines where the "stitch in time" is given to the expensive equipment with a minimum of machinery. This shop has been a great money saver. Tractors may be rebuilt; moving truck and trailers constructed; tank wagons; oil tanks and supply tanks are made by this department at comparatively low cost. The shop records are kept on the basis of a commercial shop, but the cost to the company is actual time and

[1]Paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, Chicago, December 1929.

[2]President, The Wheat Farming Co. Assoc. Mem. A.SA.E.



A Caterpillar tractor pulling three 12-foot drills, covering about 40 acres per day, on the land of The Wheat Farming Company, at Hays, Kansas. Level land and large fields as shown are an important factor in the profitable use of large power and drawn tool units. American mechanized large-scale farm production has little to fear from cheap labor competition

material which shows a saving of about 50 per cent of what the cost would be if the work were done in commercial shops.

Research Department. That the management of The Wheat Farming Company be thoroughly informed of new discoveries, new practices or new movements in the great business of agriculture, a research department is maintained which makes it its business to keep in the closest possible touch with the U. S. Department of Agriculture, with all agricultural experiment stations of the Great Plains region, with the Department of Agriculture of the state of Kansas, and with the best technical and scientific investigations and studies being pursued through organizations like the American Chemical Society and the American Society of Agricultural Engineers. It is the purpose of the company to build up for the use of its personnel as complete and as reliable a research service as possible.

In addition to the departments and divisions mentioned above there are the cost-accounting and records departments, the land inspection and purchasing department, and the marketing division, to which attention will be called.

Present Trend. The present trend of the great industry of farming is toward mechanization. It is the last great industry to utilize power. Power surveys and appraisals by the government and other agencies indicate that there is available or being made available quantities of mechanical power in constantly enlarged units. At the same time the units are becoming more reliable and tillage and harvesting equipment satisfactory for operation with these large power units is being provided. The application of power to transportation made it cheap and profitable. The application of power to mining, to the oil industry and to the steel industry made the products of each cheap, and at the same time made the profits of the industry greater. This is about to happen in farming, where operations can be conducted on level, fertile, fairly well-drained acres, especially on those lands of the Great Plains where the question of nitrogen fertility is not so vexing as upon lands which need constant application of fertilizer.

Future Trends and Possibilities. Future trends of agriculture where large bodies of level land are thus accessible indicate a going over to mass production and mechanization with expert management, not necessarily corporate farming, but, let us say, large-scale farming; farming that reduces the cost of preparation of the soil, makes timeliness possible and is directed by a management which is as careful of loss of time as it is of loss of money. There will be plenty of place for smaller operations where power in such large units cannot be used, but where expert management together with the largest use of power possible to these smaller farms will make the smaller agricultural units produce to the limit as berry, fruit, vegetable, dairy, seed, and other specialty farms.

Timeliness is all Important. In our own experiences and in the information that it is possible to obtain from all other sources, there is nothing so important in the whole agricultural program as timeliness—timeliness of preparation, timeliness of weed destruction, timeliness of cultivation for moisture conservation. There are arrays of evidence from every side but none speaks more forcibly than the data made up from the results of an experiment conducted over a period of nine years (1912-1920) at the Kansas State Agricultural Experiment Station, presented at the top of the next column.

The facts indisputably set forth in this chart need no argument. They demonstrate that in the production of wheat, and the same is also true in the production of barley, corn and the grain sorghums, ability to perform

FIELD No. 1	FIELD No. 2	FIELD No. 3
Plowed July 15.	Plowed September 15.	Disked October 1.
Kept weed free.	Kept weed free.	No attention to weeds.
Sown October 1.	Sown October 1.	Sown October 1.
Nitrates in top 3 ft. On day sown—113.3 lb. per acre.	Nitrates in top 3 ft. On day sown—43.9 lb. per acre.	Nitrates in top 3 ft. On day sown—25.8 lb. per acre.
Moisture in surface foot—22.3%.	Moisture in surface foot—20.8%.	Moisture in surface foot—19.8%.
Average yield—18.6 bu. of 14.1% protein wheat.	Average yield—14.2 bu. of 12.2% protein wheat.	Average yield—7.9 bu. of 12.1% protein wheat.
Average value of wheat grown each year, $21.39, average price	Average value of wheat grown each year, $16.33, average price.	Average value of wheat grown each year, $9.08, average price.
Price per bushel on K. C. market April 3, 1928 basis, this grade wheat: No. 1 dark 14% protein, $1.75.	Price per bushel, on K. C. market, April 3, 1928, basis this grade wheat: No. 1 dark hard 11.85% protein, $1.45.	Price per bushel, on K. C. market, April 3, 1928, No. 2 hard, of 12.2% protein, $1.46.

1927 Cost of Producing Wheat

("Crop and Markets," Vol. 5, No. 6, p. 196. For west north central division—Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska and Kansas)

Number of reports	1,168
Average acreage per farm	90
Yield per acre (bushels)	15
Cost	
Prepare and plant	$3.20
Harvest	3.88
Market	.89
Miscellaneous labor	.14
Fertilizer and manure	.67
Seed	1.71
Land rent	4.86
Miscellaneous costs	2.15
Total	17.50
Credit per acre for by-products	.55
..et cost per acre	16.95
Net cost per bushel (yield, 15 bu.)	1.13

Cost of Producing Wheat in 1926, 1927 and 1928 According to a Composite Report of Several Wheat Belt Farmers of Larger Acreage

(Basis 1000 Acres)

(Information furnished by Caterpillar Tractor Company)

One-way plowing, 1000 acres—30-hp. tractor	167 hr.
One-way plowing, 1000 acres (2nd time)	167 "
Drilling 1000 acres—three 10-ft. drills	77 "
Harvesting—1000 acres—tractor and combine	167 "
Total	578 "
Add for combine and operator	167 "
Total hours, tractor and combine	745 "
at $1.27 plus 50c (operator)*	$1,318.65
Depreciation on tillage and seeding	300.00
Taxes on land and equipment	500.00
Use of land, 6 per cent on valuation of $30	1,800.00
Seed, 45 bu. per acre at $1.66 per bu.	1,250.00
No credits taken	
Total cost	$5,078.00
Acre cost	$5.078

Average yield of areas included more than 12 bushels.
*$1.27, the suggested cost per hour for operation of Caterpillar "Thirty", omitting depreciation and interest reserve, but including wage paid operator.

the needed operations on time and in time is the key to success; and failure or inability to do so is the cause of loss.

One phase of the experiments covered in the chart above referred to is that of accumulation of nitrate fertility in wheat land soils which have had early preparation. Without going into all the scientific considerations of the question, let us say it is now known that this added fertility comes through the operation of soil bacteria of the general class known as azotobacter, and it has been shown that these bacteria are capable of and do take nitrogen from the air and fix it in the soil available for plants, especially for the wheat plant which needs a large supply for the production of the high per cent of protein that good wheat requires. Experiments are in progress in several of the state experiment stations, especially in Kansas, which are beginning to throw definite light upon the importance of this phase of soil activity.

Acre Costs. So much has been written and printed and so much has been contended concerning high acre costs of producing wheat in particular that it is with much care I set about estimating or computing such costs for our operations; that is, for operations on The Wheat Farming Company's land and under its management.

Upon consulting the Department of Agriculture about costs published through its bulletins, and upon investigating through its Division of Agricultural Engineering the basis used in the "Crops and Markets" reports of the cost of producing an acre of wheat in the north central group, which includes Kansas, it seems best to submit the estimates of these different agencies in order that they may be compared item by item with our own costs. These cost data are shown in the tables.

Cost of Producing Winter Wheat in Great Plains

(U. S. D. A. Bulletin No. 1198— Table 13. Summary of average net cost per acre and per bushel to owner operators winter wheat, 1920.)

Items	Kansas		
	Thomas County	McPherson County	Pawnee County
Average yield per acre (bu.)	14.1	14.6	12.1
Operating expense per acre:			
Labor and power			
(a) prepare land and and seed—			
Man labor	$ .49	$1.72	$ .87
Horse power	.80	2.60	1.45
Contract labor	.21	.23	
(b) Harvest and market			
Man labor	2.53	2.79	3.36
Horse power	1.08	1.09	1.09
Contract labor	1.08	.04	.47
Material cost			
Seed	1.59	2.44	2.27
Binder twine	.01	.26	.06
Manure, straw and fertilizer	.01	.25	.04
Threshing	2.10	2.53	2.34
Other costs			
Taxes and insurance.	.24	.98	.70
Special crop insurance	.49	.15	.33
Use of general farm machinery	.71	1.53	1.25
Use of tractor and combine	.28	.38	.24
Lost on abandoned acreage			2.47
Overhead	1.48	2.10	1.78
Total	13.10	19.09	18.72
Credits	.37	.10	.69
Net operating expense			
Per acre	12.73	18.99	18.03
Per bushel	.90	1.30	1.49
Interest on investment			
Land and machinery	5.10	10.63	6.59
Net cost, including interest			
Per acre	17.83	29.62	24.62
Per bushel	1.26	2.03	2.03

Cost of Producing Wheat in 1929

(Data of The Wheat Farming Company)

Acre basis	
One-way plowing	$ .338
One-way plowing	.338
Planting (drilling)	.291
Harvesting (combining)	.747
Marketing (16.7 bu.)	.835
Depreciation (equipment), interest, taxes, repairs, and obsolescence	.405
Land tax	.25
Land rent* (6% on $30 valuation)	1.80
Materials:	
Seed (45 lb at $1.66 per bushel)	1.25
Twine	
Manure	
Fertilizer	
Crop insurance	
General overhead	.50
Credits (pasturage and oil)	
Total	$6.75

15-year average 600-acre commercial field Ft. Hays Experiment Station ..... 16.7 bu.
18-year average U. S. Experiment Station 40 tracts ..... 18.2 bu.
Colby Experiment Station average ..... 19.2 bu.
*Oil rents and pasturage disregarded.

Methods of Computing Depreciation Allowance. 1.

Method used by The Wheat Farming Company:	
The propelling unit for rigs of the type used by The Wheat Farming Company represent a cost of	$2,750.00
In all operations except combining they use tillage equipment of an average value of ..	360.00
Total	$3,110.00
Twenty per cent of this, covering depreciation, repairs, breakage, new parts, taxes, interest on investment, etc.	$622.00
$622÷7500 (approximate acreage covered per year by one outfit) equals	$0.08001

2. Method submitted by a large tractor manufacturing company as derived from owner cost records, assuming 10,000 hours life for the tractor:

Depreciation cost per working hour (tractor cost, $2755)	$ .275
Interest 6 per cent on entire investment, per working hour	.186
Repairs per working hour	.15
Repair labor, per working hour	.065
Total	$ .676

An average work accomplishment of 6½ acres per hour will give 10 cents (approximate) depreciation allowance for each work acre accomplished.

Average Acre Cost

As reported from labor and material reports of unit-foremen on The Wheat Farming Company operations

One-way plowing and packing	$ .468
One-way plowing only	.338
Breaking sod	.73
Blank listing	.398
Combining	.747
Weeding	.338
Listing corn	.338
Planting corn	.38
Ridge busting	.315
Drilling	.291
Listing kaffir	.42
Planting kaffir	.425
Planting feterita	.41
Listing feterita	.77
Swathing	.37

The actual labor, fuel, lubricating and depreciation costs for an acre of wheat are:

One-way plowing immediately following harvest	$ .338
One-way plowing to destroy weeds during August	.338
Drilling at best drilling date	.291
Harvesting with 20-ft. combine	.747
Depreciation and operation plus one extra account combine (20 per cent on machinery and equipment plus interest plus investment plus tax)	.40
Marketing (basis of yield, 16.7 bu.)	$ .835
Total mechanical costs per acre	$2.949

To this should be added land rent, seed, tax and overhead.

Wheat Not the Only Crop. Large-scale farming through its demonstrated ability to cover large areas quickly and at the same time to do the work in a superior fashion—at a fraction of former costs—has made the growing of other crops than wheat reasonably sure, and also profitable. For example, corn used to be little grown in our area; it is now assuming a much more important place in the farm scheme. Two early treatments with the one-way disk plow of land intended for corn destroys the weeds, conserves extra moisture, develops more available plant food, and does away with frequent cultivations thereafter, generally requiring but sufficient to level back the ridges.

There will be those who will immediately contend that corn cannot be grown without cultivation. That all depends. If the field is clean of weeds and if the crop shades the soil, experiment shows that cultivation is perhaps a waste of time. Some typical results are shown in one of the tables above.

There Will be no Surplus. In years past this nation has had an exportable surplus of wheat which has raised in the minds of many the question of surplus production. But Science, particulary chemistry, which is making over all of the industries, is extending its influence to agriculture and to the products of agriculture. Corn which has been a source of feed for animals and food for man, is being used by millions of bushels to manufacture products unknown but a few years ago, and certainly not known as coming from corn. For example, in Indiana is a large industry being developed, the sole business of which is to manufacture butynol, a chemical solvent used extensively in the paint, varnish and lacquer industries. A new book, entitled "Farm Products in Industry," is the first book ever printed on cornstalk paper. Here are but two examples of new uses that are being made of farm products. It goes without saying that wheat, a product having from 12 to 16 per cent of protein, the most expensive necessary food element required, will not remain a surplus product very long with the price of animal protein going to higher and higher levels.

CONCLUSIONS

The experience of The Wheat Farming Company shows that:

1. The cost of the major farm operations can through power equipment and management be tremendously reduced.

2. The ability to cover large areas cheaply and quickly (day and night operation) is made possible through power machinery and production is thus increased and made much more certain.

3. One of the chief means of farm relief is to come through lowered production costs.

4. Large-scale operation requires level or almost level lands and large fields.

5. American mechanized, large-scale farm production has in the end little to fear from even the cheapest foreign labor production.

6. By holding production outlay down to a low level, corporate farming can be as profitable to its investors as are other stable lines of industry.

Results of Corn Experiments in Indiana
(Cultivation vs. non-cultivation)

Name of Experimenter	Year	Yield of Grain in Pounds: Cult.	Yield of Grain in Pounds: Uncult.	Acre in Bushels: Cult.	Acre in Bushels: Uncult.
Purdue Exp. Sta., Lafayette, Ind.	1905	370	355	46.97	45.04
	1907	1077	1,118	77.00	79.80
	1908	4375	4,200	62.60	62.20
	1909	2940	2,947	42.00	42.10
W. B. Anderson, Velpen, Ind.	1909	337	460	48.10	65.65
	1910	804	798	62.80	62.20
	1911	1014	1,014	74.30	72.40
W. D. Littlejohn, Kentland, Ind.	1909	171	163	73.80	70.40
W. S. Ratcliff, Richmond, Ind.	1910	92	114	42.00	52.00
	Total	11,180	11,169		

Four-Year Average Yield, Purdue Experiments (1906, 1907, 1908, 1909)

Cultivated plots .....57.0 bu. per acre
Uncultivated plots .....56.3 bu. per acre
Weeds not removed .....22.4 bu. per acre (3-year average)

Artificial Curing of Hay

IN A letter to the Secretary of the American Society of Agricultural Engineers, commenting on papers and reports presented at a recent meeting of the Power and Machinery Division, Dr. W. J. Spillman, chief agricultural economist, U. S. Department of Agriculture, writes:

"****** I was particularly interested in the report of your Committee on Hay and Forage Crop Drying. I hope that committee will pursue its work with vigor. There is a large section of the United States, namely, the eastern half of the cotton belt, in which farmers do not produce enough hay to feed their work stock except in certain restricted localities, the reason being the difficulty in curing hay with 50 to 60 inches of rainfall annually. For twenty years I have been urging the importance of work along this line. Now that the boll weevil has reduced the income from cotton, particularly in the low lands of the Southeastern states, it has left many farmers in a precarious situation. The only thing available to them when cotton is taken away is some form of livestock farming, and that means hay and pasture. The development of a satisfactory equipment for curing hay artificially would go a long way towards making livestock feasible on farms in that section of the country.

"Not only that, but wherever hay is grown, even in the West, where ideal curing weather is ordinarily expected, artificially cured hay is of such superior quality and the loss of leaves from alfalfa hay is reduced to such a minimum as to make artificial curing worth consideration, even in the western alfalfa country.

Some Fundamental Factors Determining the Effective Capacity of Field Machines[1]

By E. G. McKibben[2]

WHILE it is obvious that the effective capacity of a field machine is some function of (1) width, (2) operating speed and (3) interruptions, the relationships between these factors under varied field conditions are not always so evident. For example, it has been the common experience of operators that the effective capacity of a field machine is frequently not increased in proportion to increases in either its width or its operating speed.

Capacity of Field Machines. An equation for the effective daily capacity of a field machine can be easily derived as follows:

$$C=\frac{(5280)(S)(W)}{43{,}560}=\frac{(S)(W)}{8.25} \quad \ldots\ldots [1]$$

where C is the uninterrupted hourly capacity in acres, S is the speed in miles per hour, 5280 is the equivalent of a mile in feet, 43,560 is the equivalent of an acre in square feet, and W is the width of the implement in feet.

$$X=\frac{(S)(W)(100-P)}{(8.25)(100)} \quad \ldots\ldots [2]$$

[1]Paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, Chicago, December 1929.

[2]Associate professor of agricultural engineering, Iowa State College. Mem. A.S.A.E.

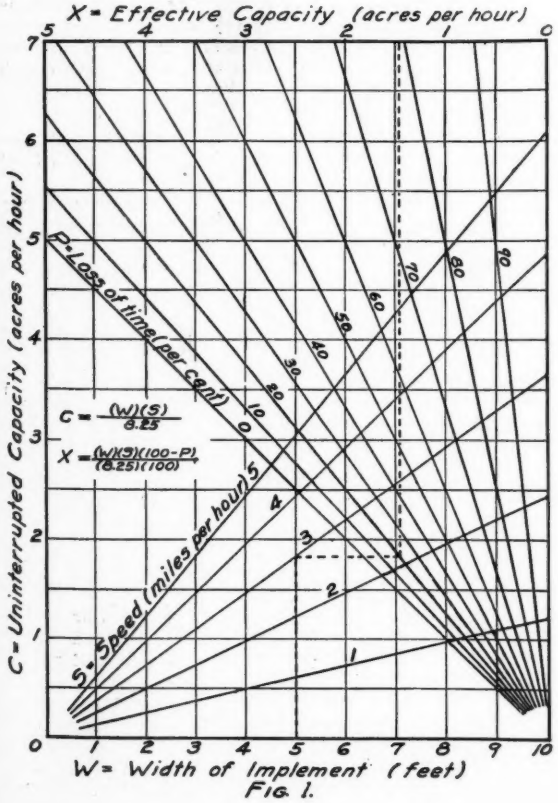

X = Effective Capacity (acres per hour)
C = Uninterrupted Capacity (acres per hour)
W = Width of Implement (feet)
P = Loss of time (per cent)
S = Speed (miles per hour)
C = (W)(S)/8.25
X = (W)(S)(100-P)/(8.25)(100)

Fig. 1.

where X is the effective hourly capacity in acres, and P is the per cent of time lost because of interruptions.

$$Z=\frac{(S)(W)(H)(100-P)}{(8.25)(100)} \quad \ldots\ldots [3]$$

where Z is the effective daily capacity in acres, and H is the length of working day in hours.

If P, the per cent of operating time lost by interruptions, is taken as 17.5 (a reasonable value for many operations), and H, the length of the available working day in hours as 10, Equation 3 becomes

$$Z=\frac{(S)(W)(10)(100-17.5)}{(8.25)(100)}=\frac{(S)(W)(10)(82.5)}{(8.25)(100)}=(S)(W) \quad \ldots\ldots [4]$$

Thus it is convenient to remember that the daily performance in acres of a field machine can be approximated by multiplying the width in feet by the operating speed in miles per hour.

Fig. 1 shows a chart by which the relationship between width, speed, per cent of interruptions, and hourly performance can be readily determined for all conditions within the range of the chart. The dotted lines show the method of using the chart and indicate the hourly performance of a 5-foot machine operated at 3 miles per hour where 20 per cent of the time is lost because of interruptions.

Length of Field. The length of the field affects the capacity of machines because of the relationship which

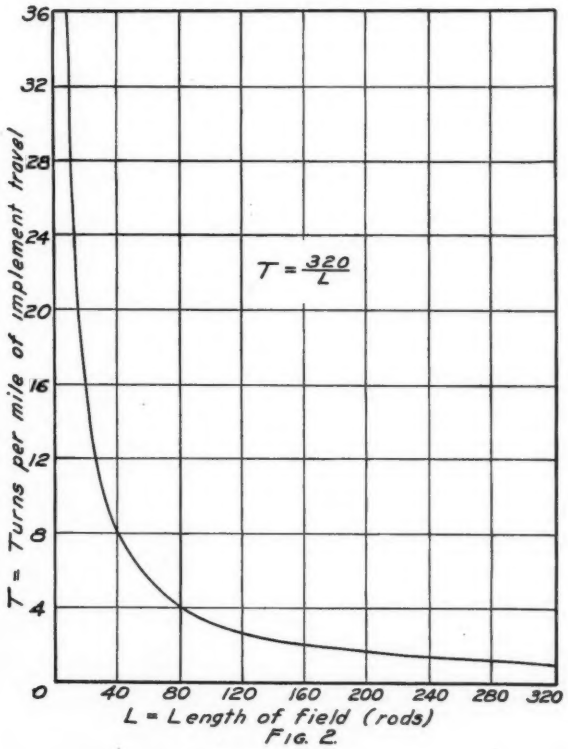


Fig. 2.

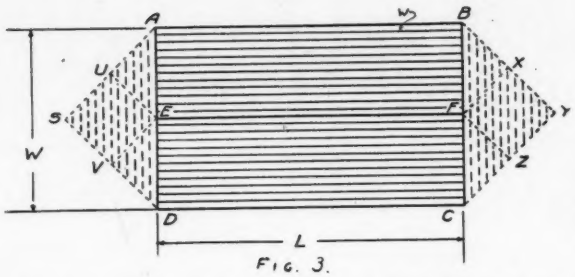


Fig. 3.

exists between the field length and the number of turns for a given distance of effective machine travel, and between the field length and the per cent of idle travel at the ends.

Turns at the end of the field, under most conditions, represent an important but unavoidable interruption. This is particularly true for short fields. The number of turns, T, per mile of travel, which is proportional to the area worked by a given machine, is

$$T=\frac{320}{L} \quad \text{..... [5]}$$

where L is the length of the field in rods. Fig. 2 shows the relationship between T and L. From this curve it is evident that extremely short fields result in an excessive number of turns.

Idle travel at the ends represents another interruption which is often unavoidable. This item is particularly important where wide lands are used in short fields. An equation for the idle travel, P, expressed as per cent of the total travel, can be derived as follows:

The effective travel in rods per land is $(LW \div w)$, where L is the length of the field in rods, W is the width of the land in rods, and w is the width of the implement in rods. Using the same symbols, the idle travel is $(0.5\,W_2 \div w)$, and the total travel is

$$\frac{LW}{w}+\frac{0.5W^2}{w}, \text{ or } \frac{LW+0.5W^2}{w} \text{ (Fig. 3).}$$

$$\text{Therefore, } P=\left[\frac{0.5W^2}{w}\right]\left[\frac{w}{LW+0.5W^2}\right](100)=\frac{50W}{L+0.5W} \quad [6]$$

where P is the idle travel as per cent of the total travel. Fig. 4 shows the relationship between width of land, length of field and per cent of idle travel. It should be noted that the short field again offers a definite handicap, also that lands should be kept as narrow as practicable. In fact, from the standpoint of maximum capacity the use of lands should be avoided wherever practicable.

However, in connection with field length we must not overlook the fact that, for fields of equal area, the square field has the least fence and fence row, and the fact that under certain conditions there is some advantage in being able to work the field in both directions.

Interruptions Proportional to Area. The effect of interruptions, which tend to be proportional to area, upon the capacity of wider machines and higher speed machines is one of the most important and least understood of the reasons for the disappointing results often experienced in using such machines under adverse conditions. While there are very few cases where interruptions are actually proportional to area there are many situations where the interruptions tend to assume this characteristic. For example, interruptions caused by stones, stumps, weeds, trash, filling of seed and fertilizer boxes, inferior construction, inefficient operation, careless maintenance, etc., often tend to be proportional to area and under certain conditions may actually become proportional to area. Again, if an attempt is made to increase the capacity

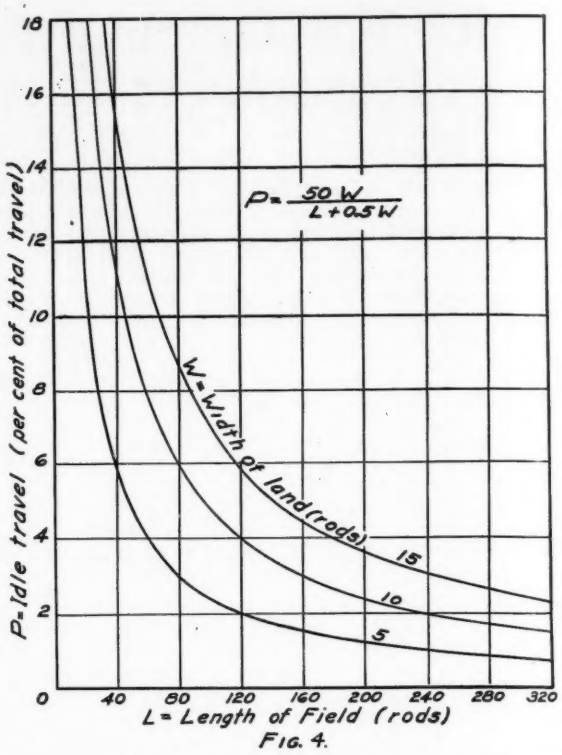


Fig. 4.

of a machine by increasing its operating speed without decreasing the time required for turning and other routine interruptions, the time lost in such interruptions becomes proportional to the area. In general this type of interruption is probably more important in connection with row-crop machines. However, under certain operating conditions it affects almost all field machines.

The relationship between effective capacity, uninterrupted capacity, and interruptions which are proportional to area may be developed as follows:

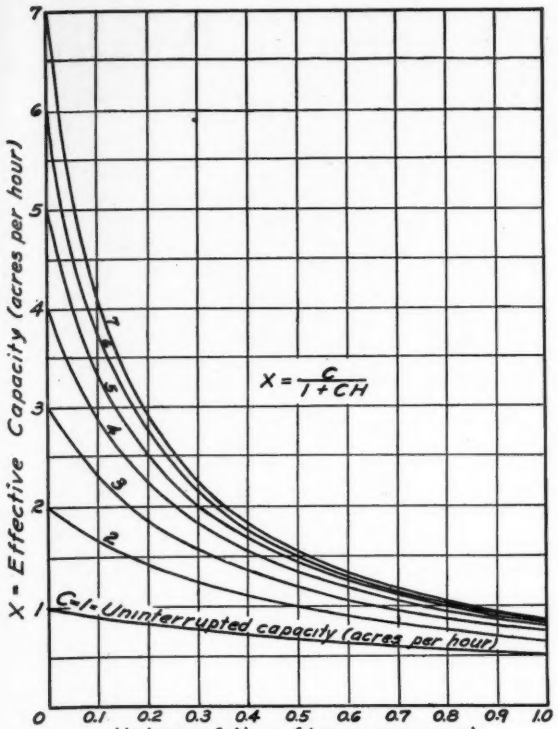
Let C=uninterrupted capacity of machine in acres per hour
H=loss of time per acre, in hours per acre
X=effective capacity, in acres per hour
Y=time required per acre under operating conditions, in hours
P=effective capacity in per cent of uninterrupted capacity.

$$\text{Then } Y=\frac{1}{C}+H=\frac{1+CH}{C} \quad \text{..... [7]}$$

$$\text{and } X=\frac{1}{Y}=\frac{C}{1+CH} \quad \text{..... [8]}$$

$$P=\frac{\frac{C}{1+CH}}{C}=\frac{1}{1+CH} \quad \text{..... [9]}$$

Fig. 5 is a graphic presentation of Equation 8 and shows emphatically the increasing penalty which higher capacity machines place on adverse field conditions, inferior construction and careless operation and maintenance. Note that under conditions where the loss in time per acre is one hour a machine with an uninterrupted capacity of one acre per hour (for example, a single-row cultivator) will accomplish 0.5 acres per hour, 50 per cent of its uninterrupted capacity, while a machine with an uninterrupted capacity of 5 acres per hour (such


X = Effective Capacity (acres per hour)
X = C / 1+CH
C=1 - Uninterrupted capacity (acres per hour)
H = Loss of time (hours per acre)
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
1 2 3 4 5 6 7
FIG. 5

as a five-row cultivator) will accomplish only 0.83 acres per hour, less than 17 per cent of its uninterrupted capacity.

Even a casual study of the agricultural development during the last one hundred years indicates that, as the capacity of machines has increased, the penalty on adverse farming conditions and inefficient operation has increased. If all wheat growers were required to use low capacity implements such as the cradle and flail, the small, rough, stony fields of the Pennsylvania valleys could probably compete very successfully with the great level plains of Montana. If all corn were to be cultivated by the "man with the hoe" the best corn fields in Iowa would not have a great advantage over certain small, stony fields of New York. However, with the combine and the multiple-row power cultivator available the situation has changed. Relatively speaking, poor farms and poor farmers have become poorer and good farms and good farmers have become better. The gap between the extremes has steadily increased.

CONCLUSIONS

1. The daily capacity of a field machine in acres can be approximated by multiplying its width in feet by its operating speed in miles per hour (Equation 4).

2. As the length of a field is decreased the number of turns increases as the reciprocal of the length of the field, so that turns become a very important cause of time loss in short fields (Equation 5 and Fig. 2).

3. In short fields which are handled as lands the idle travel across the ends represents a relatively large loss. This is especially true where comparatively wide lands are used. (Equation 6 and Fig. 4).

4. Interruptions which tend to be proportional to the area worked increase rapidly in importance as the capacity of the machine is increased (Equation 8 and Fig. 5).

5. Thus, if the operating speed is increased, the time for all routine interruptions must be decreased in the same ratio, if the same per cent of the uninterrupted capacity is to be maintained.

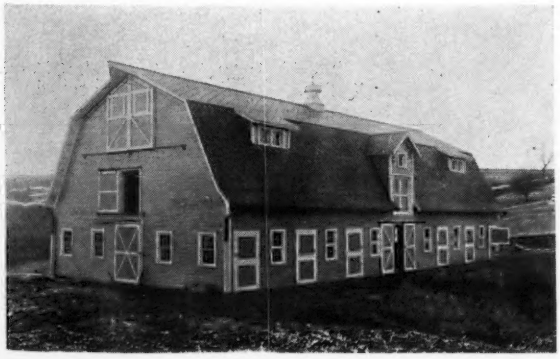
6. And, if the width is increased the time required for all routine interruptions must not be allowed to increase if the same per cent of the uninterrupted capacity is to be maintained.

7. High capacity machines should not be expected to give satisfactory performance where interruptions are frequent and proportional to the area worked.

8. As the capacity of field machines is increased the penalty for adverse field conditions, inferior construction, and careless operation and maintenance; and the reward for good land, superior construction, and efficient operation and maintenance, increases. In other words, if it is to succeed, big farming must be better farming.

Agricultural Engineer Designs New Sheep Barn

WORK has just been completed on the new sheep barn erected on the animal husbandry farm at West Virginia University. For years the experimental work with sheep on the state farm has been hampered by lack of adequate housing facilities. The new building is designed to lend itself to almost any type of research project with sheep and provides ample housing facilities for the entire experimental flock. Storage space for feed and equipment is also provided.


The new sheep barn at West Virginia University nearly completed

Some special features of the design are the attendant's room, toilet and washing facilities, shearing floor, dipping vat, feed racks, the pen railings and the ease of converting the interior pen space from small into large enclosures, or vice versa.

One unusual feature in this design is the provision whereby the south side of the barn may be opened for air and sunlight. The openings are screened with heavy wire frames. In inclement weather all of these openings may be closed by rolling steel doors hung inside the frames.

The barn has just been put into service and when all grading is done, retaining walls built, and roads and courts cindered it is felt that West Virginia will have facilities for carrying on research with sheep comparable to those possessed by other states.

This barn was designed by F. D. Cornell (Assoc. Mem. A.S.A.E.), agricultural engineer of West Virginia University.

The General-Purpose Tractor in Potato Production in Pennsylvania[1].

By R. U. Blasingame[2] and H. B. Josephson[3]

THIS is the third year we have grown a crop of potatoes at the Pennsylvania Agricultural Experiment Station using the general-purpose tractor for all operations[4]. When we began the farm power and labor studies in the fall of 1925, no potato equipment was available for the general-purpose tractor. To bring this equipment up to the required standard of perfection a project was outlined which is divided into two objectives: (1) To study and adapt the general-purpose tractor and its equipment to potato production, and (2) to study the economic phases of growing potatoes with a general-purpose tractor using the equipment selected or developed under the first study as compared with common Pennsylvania practices. This paper reports progress on the first study. We propose to grow about 15 acres of potatoes next year, or a sufficient acreage from which to obtain reliable cost data.

This work is being done in cooperation with Dr. C. F. Noll, superintendent of the College farms and Dr. E. L. Nixon of the botany department, division of plant pathology research. Our efforts this year were concentrated on methods and equipment rather than costs. Many of the difficulties previously encountered were largely overcome and we feel that this year's work in motorizing the production of the potato crop has been highly successful.

Following are some of the most difficult requirements to meet in using a tractor in potato production:

1. Keeping the soil loose throughout the growing season
2. Prevention of damage to vines
3. Weed control within the rows.

These requirements were satisfactorily met. The crop got a good start and we had a fine growth of vines. However, an unusually dry season prevented anything like a normal growth of tubers. Only 4.28 inches of rain fell between June 24 and September 7. A measured acre yielded 209 bushels. The average yield from the field was 170 bushels per acre, which was higher than that obtained on an adjoining field where standard practices were employed and power was supplied by teams.

Preparation of Seedbed. The field which was in clover sod, was plowed 8 inches deep late in April. The spring tooth harrow was then used, followed by a disk harrow of large diameter to cut up the sod. Immediately before planting the ground was "jostled" to a depth of about 10 inches. The shanks of the "jostler"[5] were placed 12 inches apart. The purpose of this operation was to loosen the soil thoroughly before planting. This is especially advantageous when rains have packed the soil subsequent to plowing. For this operation the general- purpose tractor was not powerful enough for the large-size jostler available and a 20-horsepower tractor was substituted.

Planting. A two-row planter (Fig.1.) was used, spaced for 34-inch rows. This row spacing is wider than that used by the majority of potato growers in the state, but it was not considered practicable to plant in narrower rows when using this general-purpose tractor. With the wheel equipment used the tread of this tractor is 68 inches.

Cultivating and Weeding. Two weeks after planting, before the potatoes were out of the ground, the field was gone over with a stiff-tooth cultivator and weeder in one operation (Fig. 2). The guiding was done by following the planter wheel marks. Only three cultivator teeth were used for each gang. These were set about 4 inches deep, the object being to loosen up the soil in the wheel marks left when planting. The center section of a tractor weeder was used on the rear of the tractor. This double operation was repeated when the potatoes were just out of the ground.

The weeder was used every week until the potatoes were more than a foot high, three times in conjunction with the stiff-tooth cultivator and three times without the cultivator, using the extension wings (Fig. 3).

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[1]Paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, Chicago, December 1929. Publication authorized by the Director of the Pennsylvania Agricultural Experiment Station as Technical Paper No. 487.

[2]Professor and head of the department of farm machinery, Pennsylvania State College. Mem. A.S.A.E.

[3]Agricultural engineer in charge of field machinery research, Pennsylvania State College. Mem. A.S.A.E.

[4]For reports of previous work see Pennsylvania State College and Experiment Station Bulletin 238, entitled "Farm Power and Labor."

[5]Also known by the names "cultivator chisel" and "orchard harrow."

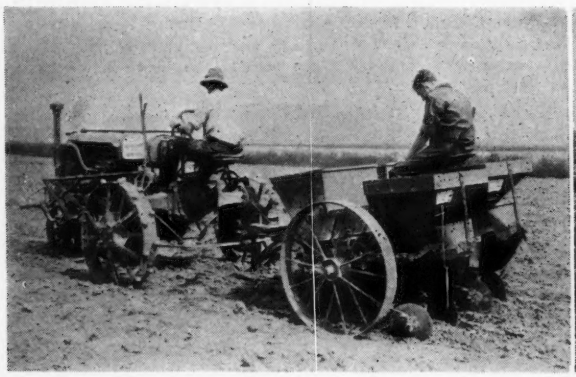


Fig. 1. (Left) Planting the potatoes with a two-row planter in 34-inch rows. Fig. 2. (Right) Using the stiff-tooth cultivator and weeder before the potatoes were out of the ground

Fig. 3. (Left) The weeder was used every week until the plants were more than a foot high, three times with and three times without the cultivator. Fig. 4. (Right) The spring-tooth cultivator stands the abuse of stony ground but does not, on this machine, leave the drawbar free for mounting the weeder

A spring-tooth cultivator was used twice (Fig. 4). This type of cultivator stands up under our conditions of stony ground better than the stiff-tooth cultivator, but it has the disadvantage of having some of the teeth at the rear so that the drawbar is not free for mounting the weeder.

The weeder was found to be a most effective weed controller. When it was used every week the cultivator was required only to keep the soil loose between the rows. Tractor wheel marks must be loosened up occasionally by the cultivator.

Spraying. An eight-row 200-gallon sprayer was used, driven through the power take-off. The sprayer pump had a capacity of 16 gallons per minute and was operated at a pressure of 450 pounds per square inch. Spraying was done weekly from the time the plants were about 4 inches high until the vines were killed by frost, a total of sixteen applications (Fig. 5).

Vine Lifters. The vine lifters supplied with the tractor cultivator were found effective in preventing damage to the vines (Fig. 6). These were used when cultivating and spraying after the vines had started to spread. During the latter part of the growing season the vine lifters were given a particularly severe test as the vine growth was very heavy. Care was taken that the sprayer was always driven between the same rows and in the same direction. This is important because the vines can be trained to lie in a certain way. The sprayer wheels were also provided with vine lifters (Fig. 7). The hooks shown in the picture are made of ¾-inch pipe. These must be far enough in front of the wheels to lay the vines aside. A rod extending back from these hooks was found to be effective in preventing the vines from falling back under the wheels.

Harvesting. A one-row digger was used, driven through the power take-off. The extension elevator was removed and a mechanical "potato picker" attached (Fig. 8). This machine consists of a separating table and a narrow conveyor on each side into which the potatoes are picked. The potatoes are carried into sacks hung at the rear of these conveyors. Four men worked on the machine, picking the potatoes from the stones and clods. One man was kept busy removing the vines. The other three men could keep up only when the tractor was throttled down to one mile per hour or less in low gear. The yield was around 200 bushels per acre. (In normal seasons yields of 400 bushels per acre are commonly obtained.) Although the capacity of this picker is entirely inadequate for our conditions we believe that the principles involved are correct and that it may be redesigned and made into a practical machine, even for heavy yields.

Slow Forward Speed for Harvesting. It will likely be difficult to design a mechanical potato harvester having enough capacity for a speed of 2 miles per hour in heavy yields. Our tests indicate that one mile per hour would be more nearly the correct speed. When using a tractor having a normal low speed of 2 miles per hour this must be obtained by driving the tractor with the engine running at one-half rated speed. An alternative is to provide a fourth speed giving the required forward speed. Obviously the second solution involves mechanical difficulties. The increased gear ratio would double the available drawbar pull, which would subject the transmission to stresses

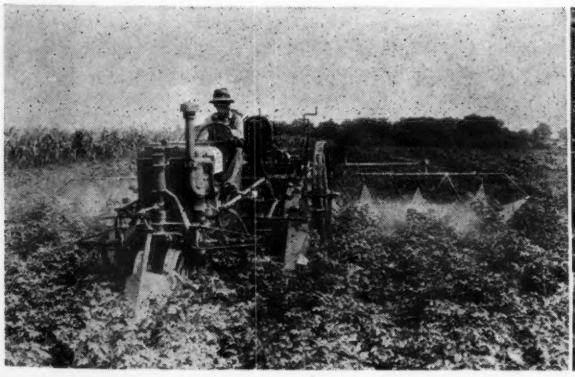


Fig. 5. (Left) Spraying was done every week, a total of sixteen times, with an eight-row sprayer, the pump of which was driven through a power take-off. Fig. 6. (Right) Vine lifters furnished with the tractor cultivator were effective in reducing damage to the vines

Fig. 7. (Left) The type and arrangement of vine lifters used on the sprayer wheels. Fig. 8. (Right) Trying the mechanical potato picker

for which it was not designed, furthermore, it would make the tractor less safe to operate. Some method of limiting the torque through this fourth speed would be necessary. This might be accomplished by means of a slip joint incorporated in the fourth speed gear train.

Potato Loader. A mechanical potato loader was also tried. It was attached to the rear of the digger. It consists essentially of an elevator similar to that of a digger, a side elevator for carrying the potatoes, and mechanism for removing the vines. The potatoes were loaded on a wagon also drawn by the tractor. On the wagon was a conveyor 15 inches wide driven by a small gasoline engine which served as a separating table. The potatoes, together with clods and small stones, were delivered from the loader to the front of the conveyor, from which the potatoes were picked while the trash was carried over the rear end of the conveyor to the ground.

The general-purpose tractor did not have sufficient traction to pull the digger, loader and wagon when the latter was loaded. The mechanical vine separation was not satisfactory; the outfit required too much space for turning, and on the whole the results of the experiment were not encouraging.

Improvements in Equipment. Considering the brief time during which the tractor has been given consideration in potato production we feel very much encouraged over the improvements that manufacturers are effecting in potato equipment for the general-purpose tractor. An outstanding example is that the manufacturer of the tractor weeder used in this work has during this year rebuilt an experimental machine twice, each time coming nearer to the real requirements of the machine as determined in this project.

Reduction in Lumber Losses Assured Through Preserved Wood Distribution Program

MILLIONS of dollars now lost annually in Ohio as a result of attack of insects and decay of lumber will be saved as a result of the movement just inaugurated by the National Committee on Wood Utilization of the U. S. Department of Commerce to insure the distribution of chemically treated lumber in that state. Ohio architects, engineers, builders, lumbermen and wood conservationists are cooperating with the committee in this movement, which is being carried out under the direction of a special subcommittee of which T. F. Laist (Mem. A.S.A.E.), architect, and director of research in retail lumber, Antioch College, Yellow Springs, Ohio, is chairman.

Heretofore preserved wood has been available in wholesale quantities only, and has been used for decades by railroads, public utility organizations and similar large consumers of lumber. To give small consumers access to an available supply of such wood, the committee's plan has been put into operation.

Arrangements have been made to have this wood distributed by the Ohio Retail Lumber Dealers Association. The National Lumber Manufacturers Association is keenly interested in the movement particularly through its affiliation with the American Wood Preservers Association. It has been active in the arrangements in Ohio and looks for the spread of the movement to other states. Through the cooperation of Louis J. Taber, Columbus, Ohio, Master of the National Grange, particular attention is being paid to the distribution of treated material to farmers, who put much lumber to uses for which preserved stock is essential.

When wood is in contact with the ground it is particularly subject to insect attack and decay, but through the use of preserved wood this danger may be minimized. Standard preservatives, such as zinc chloride and creosote, are advocated. Special attention is called to the fact that repair charges for the replacement of damaged or decayed parts of a building far exceed the small additional cost of using preserved wood in the original construction. Wherever the extension of the life of wood is desirable preserved wood should be used, the committee points out.

To protect consumers of preserved wood from fraudulent substitutions, the preserved lumber distributed under the committee's plan will be grade-marked. To provide nontechnical consumers with information on preserved wood and its uses, the committee is preparing booklets on this subject.

William Draper Brinckloe, a member of the American Society of Agricultural Engineers, represents that Society on the National Committee on Wood Utilization.

Corn Planting and Cultivating with the General-Purpose Tractor[1]

By J. Leo Ahart[2]

POWER requirements for planting corn are the lowest of all the major operations necessary in growing the crop. This is one reason why corn planting will probably be one of the last field operations in the corn belt to be generally done with tractor power. Another important point in this regard, which the practical farmer who is at present efficiently using mechanical and animal power in conjunction has in mind, is that at corn planting time the tractor had better be given a more economical load than planting corn and the horses used on the planter.

At Boni Agri our system is to turn under sweet clover in May and plant as soon as the ground can be fitted. This means that the tractors are busy fitting the fields for planting for at least two weeks after planting has begun. In the last field, the tractors and planters are usually working close together, the tractors scheduled to finish their work just ahead of the planters. This economic condition in farm management is common to the hilly section in western Iowa where we operate.

With difficult topography to deal with, planting corn with mechanical power interests us in an experimental way at present rather than as something for immediate adoption. A few farmers operating in nearby river bottoms have used general-purpose tractors of various makes for corn planting this year for the first time. Two of these outfits were in the hands of owners who are expert operators and rated among the best farmers in the county. Plenty of opportunity was afforded to observe the work done and draw conclusions.

The fields were all comparatively large, level and made trapezoidal in shape by railways and drainage ditches. As a matter of fact, a very small percentage of fields are perfectly regular in shape. Unequal lengths of rows and point rows must generally be contended with. The checking done by these outfits was not satisfactory because the steering threw the line of planter shoes off the parallel with the check rows and the seed was strung out so badly in the hill that cross cultivation took out approximately 20 per cent of the stand. This trouble of stringing the seed in the hill was not solved by either the farmers or the factory expert who stayed with two of the outfits. The two farmers referred to are progressive, financially able to buy whatever equipment they desire, and thoroughly power-farming minded. It must be mentioned that the planting attachments which they purchased on approval for their general-purpose tractors did not stay sold. If corn belt farmers generally demand that their corn must be checked, designing engineers have a real problem yet to be solved.

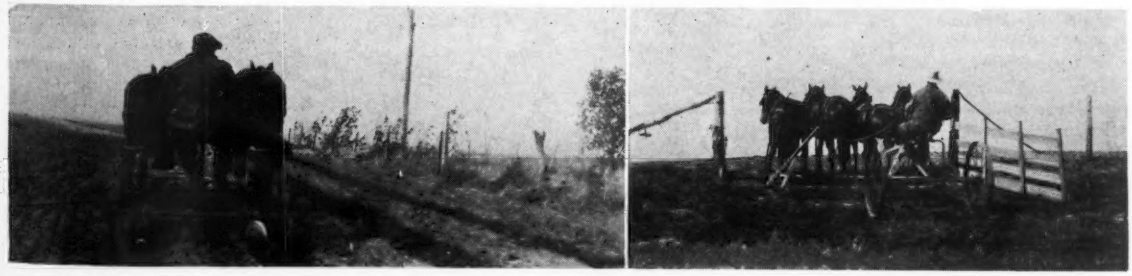
But why check corn? The only good reason under the sun for checking corn is to allow one cross cultivation to be made with a cultivator which must be operated with respect to the rows. It has been conclusively demonstrated that we cultivate rowed crops to kill the weeds rather than to maintain a mulched soil condition. We have satisfied ourselves at Boni Agri that it is not a difficult matter to control weeds in drilled corn with proper equipment and timely management. We are not, therefore, going to demand a tractor planter which must check corn efficiently. Even if such a machine were available and fully adapted to our hilly and irregular field conditions, we would much prefer the simpler and speedier drilling outfit. We shall secure such an outfit for use in planting the next crop, as it is very evident that Iowa farmers will soon have to think in terms of power farming for every operation in corn growing.

We will have to do this through necessity if for no other reason. During 1928 alone, the census of the twelve most important colt-producing counties of Iowa shows a 26.2 per cent decrease in production. The twelve counties leading in tractor population show an increase of 11.2 per cent in the same year. The present rate of colt production in Iowa, taken as a whole, is such that only one colt is becoming available for each farm but once in sixteen years and only one colt is being put to work each year for sixty-four horses already on farms. It is interesting to note that the production of mule colts last year in Ringgold county, bordering Missouri, dropped from 205 to 71. Iowa's leading county in tractor population (Webster) now has a tractor for each half-section.

Either more colts or tractors are going to be used in Iowa and present odds greatly favor the general-purpose tractor. My own opinion is that the movement of tractors to farms will be restricted only by the farmer's financial inability to purchase, and not by any lack of faith that tractor power will meet his requirements. Despite the scarcity of horses, the farmer can still buy his horse requirements for less than the cost of production. Weanling colts of ordinary quality do well to get bids at farm auctions equal to the stallion service fee. The demand

[1]Paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, Chicago, December 1929.

[2]Agricultural engineer and manager, Boni Agri Farms, (Crawford County, Iowa). Assoc. Mem. A.S.A.E.



(Left) Disk attachment on planter, showing its work and manner of attachment. (Right) Passing through a 12-foot gate with a 20-foot harrow, outer sections of the harrow and drawbar being folded in

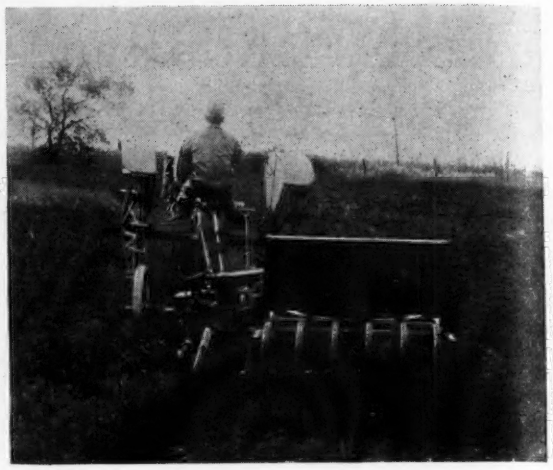
for them simply does not exist. The average farmer today is anxious to arrange his work so that he will become entirely independent of hired help. He wants privacy in his home and family. The general-purpose tractor will be more and more a factor in the realization of these desires.

Planting the seed is but one of various operations necessary to grow a corn crop. The man-hour requirement for planting is only 18 per cent of the total to grow the crop to harvest time under our best present management, and the horsepower-hour requirement is an even lower percentage of the total. We must ask that the tractor planter do a good job of drilling the seed; be fast; have the power to take the planter up a 25 per cent grade in second gear; have drivewheel equipment which will give traction and will not slide sidewise appreciably in plowed ground or pack the seedbed enough to interfere with cultivation; have front wheel equipment which will go where desired when turning in soft ground; and have the seed delivery so arranged that the operator may see at a glance what the planter is doing at any time. Attachments for drilling soybeans with the corn would be wanted for planting those fields to be hogged down at harvest time. This practice is increasing in the corn belt. It should be mentioned that some farmers who husk by hand prefer to work in checked corn. Others prefer to work in drilled corn because each stalk stands by itself. Shoats have no preference, except to consume the best areas first.

With topographical conditions such as we have, we doubt if as many as four rows to a planting unit would be practical unless each shoe did its work independently and each shoe be allowed a wide range of movement in the vertical plane. The limiting factor for a four-row outfit would be the necessity of crossing numerous ditches lying diagonally to the line of travel. If our fields were level or only slightly rolling, a multiple-row outfit would certainly be the one to use.

For some years we have used an attachment on our planters which makes a small ridge over the planter tracks and a shallow furrow on either side of each track. It consists essentially of four small disk blades attached flexibly to the rear end of the planter frame with a lever at the driver's hand with which to lift the disks on the turns. The device adds to the draft of the planter noticeably but not too much. The shallow furrows are effective in preventing the seed from being washed out by a heavy rain even on the steep hillsides and make it unnecessary to follow the planter immediately with the pegtooth harrow. Farmers in hilly sections do not sleep well at night during planting time unless their fields are harrowed up close to the planter at quitting time. We have eliminated the need for this extra harrowing by using the disk attachment. The fields are harrowed crosswise of the planter rows a week after planting, when a real job of killing seedling weeds is effected. The small ridges over the corn rows are pulled down, leaving the row well cleaned out. The results are very satisfactory if this work is done on a day when the sun is out and a breeze blowing. Harrowing immediately behind the planter kills few weeds, inasmuch as the ground has usually been fitted just previous to planting. We shall certainly adapt some such attachment to the tractor planter we will use because the advantages are too great to be neglected.

This pegtooth harrowing a week after planting is the first cultivation and the general-purpose tractor makes speedy work of the job. We look carefully to the harrow teeth and keep them drawn out to a sharp point so that they will penetrate the surface and tear out the weeds. Since we commonly follow sweet clover seeding with corn, there is no trash to contend with. The peg-tooth harrow is an efficient multiple-row cultivator when used at the proper time. Most of our gates are sixteen-foot openings and we found that much time was consumed in moving from one field to another. This was effectively taken care



Plowing, pulverizing and drilling in one operation on the Boni Agri Farms, using the Ahart method of plowing around the field

of by designing a harrow drawbar which allowed the outside sections to be folded over on top of the mid-sections for transport.

Previous to the use of the rotary hoe, we worked with weeders of different kinds to keep the weeds in check until the shovel cultivator could be used with comfort and dispatch. We find that the working principle of the rotary hoe is much more satisfactory than that of the weeder under all the varying conditions to be met. The rotary hoe does not do satisfactory work when pulled by horses unless it is chiefly desired to break up a crusty condition of the top soil. At horse speed a rotary hoe does not do enough damage to the seedling weeds to make the operation worth while. On the other hand, when drawn behind a general-purpose tractor at a speed of about four miles per hour, the results are very satisfactory if the work is done just a little sooner than seems necessary and often enough to prevent fibrous rooted weeds from establishing themselves. The rotary hoe does little or no damage to morning glories, milk weeds or cockle burs. It is effective on seedling foxtail and buttonweed. The rotary hoe is a light-draft machine and here again we have had trouble getting through gates with a machine of such width as would give the tractor an economical load. There is a five-row hoe on the market, but it could not be taken through our standard gates. We redesigned this machine to allow the outside sections to be folded over for transport and to secure more flexibility for our hilly fields.

After considerable experience with the rotary hoe we have gained faith in it as deserving a permanent place in a power-farming program. We must report, however, that these implements will have to be redesigned and built so that they will stand up under tractor usage. The malleable toothed wheel now generally employed will not stand up in service. There must be too much unsupported axle length or the axles will buckle and the gangs lock teeth. Continual need of straightening teeth and axles is aggravating to a man when he knows the time is right for effective work with the outfit. After a malleable tooth is straightened two or three times, it breaks off and the machine is that much less effective. We are doing as much experimental work with rotary hoes as individuals can do along with regular farm work. We know that drilled corn can be kept free from weeds in the row with a rotary hoe under the following management:

1. Adequate cultivation to kill weeds before planting
2. Use of sharp peg-tooth harrow one week after planting

3. Use of rotary hoe with the rows until corn stands six to eight inches high
4. Use of six-shovel cultivating equipment
5. Use of rotary hoe again with the rows
6. Laying-by with six-shovel cultivators.

Cultivating with shovel equipment after the rotary hoe is a pleasant task. The crop has grown high enough to remove the tediousness and necessity for slow speed for the first time over with the shovel equipment. The top soil is fine and moves nicely around the corn plants. The shovels should be set to leave a small ridge in the corn row. The next time the rotary hoe comes along, it will run deeper in this ridge and tear out any seedling weeds present there. By waiting until afternoon, we have followed the first shovel cultivation in corn eighteen inches high in the row without damage to the crop. The crop looked bad immediately behind the machine but was up and coming fine the next day. Sixty acres can be conveniently cultivated in a day with a five-row rotary hoe and tractor travelling in high gear and the work is all pleasure for the operator.

We have used a general-purpose tractor for shovel cultivating this year in the hills with excellent results from every standpoint. Owing to the high speed of travel, 4¼ miles per hour, Texas shovels or sweeps were used as shovel equipment. These shovels, six to the row, lapped so that everything was taken clean between the rows. No difficulty was had keeping the outfit on the rows even on the hillsides although the front shovels were set only seven inches apart and the outfit operated in high gear. As a matter of fact, horse outfits were working in the same fields and we reserved the worst hillsides and odds and end to be cultivated with the general-purpose tractor outfit, in order to give it a real tryout under adverse conditions. All hands admitted that the tractor outfit was doing the best work while making slightly less than two rounds to one for horse outfits, under favorable working conditions for the teams.

An important advantage gained by drilling corn is that all the turning at the ends for all the cultivations with the rotary hoe and shovel equipment is done at the narrower ends of the field. This means a lower mortality of the stand in the turning area, or, in case the turning area is left in grass or given to a forage crop, less land is necessary for the purpose.

The Requirements and Design of Cultivating Equipment for the General-Purpose Tractor[1]

By Theo. Brown[2]

THE day of row-crop motor cultivation is here. The demand and need of it have brought it to reality. At present there are a number of general-purpose tractors on the market designed for and built with row-crop cultivating equipment.

We find good engineering resulting in decreased weights with more efficiency and strength. Smaller tractor units have come—some with power for three and sometimes four plow bottoms, and others for two bottoms. This last size is the one best suited to the row-crop territories. And now, with a tractor of suitable size and power for this row-crop territory, it is but natural that the adaptations have been made to make it suitable to row-crop work.

Obviously to adapt the conventional tractor design to row-crop work, sufficient crop clearance and a proper wheel tread are essential. The success of the general-purpose tractor depends in a large measure upon the proper balance of its design. By this balance is meant the careful consideration to be given to the various functions the tractor is expected to perform. The result should be as nearly 100 per cent for performing all these functions as may be possible, and the results as even as can be.

In the design of a general-purpose tractor there must be compromise. For example, hanging a cultivator unit on a tractor does not give the same effect as drawing a plow from the tractor drawbar. Another example, crop clearance should be sufficient, yet the center of gravity of the tractor should be kept low. These are but two of the considerations before the designer. He must know how and when to compromise.

In considering cultivating equipment for the general-purpose tractor, we realize that the tractor takes the place of the horse. And this era of substitution of mechanical for animal power for row-crop work being more or less at its beginning, it is impossible to forecast just what the future design of cultivating equipment for general-purpose tractors will be. Yet it should be possible to state with some accuracy what the requirements are.

It is hardly necessary to dwell long on what good cultivation is and the kind of work the cultivator must do. The results to be obtained are known. Perhaps this statement will answer the purpose: Good row-crop cultivation means loosening the soil in the rows between the crop uniformly at any desired depth, in such manner as to destroy all weeds by uprooting and leaving them exposed on the surface to wither, or burying them beneath the surface, all this to be done without damage to the crop.

This may perhaps in the broadest sense express the term "requirements" of my subject. It expresses the result to be striven for. This definition does not differentiate between horse-drawn and tractor-drawn cultivators; yet, while the results to be obtained are the same an analysis of the situation reveals that many of the requirements to be met in the cultivating equipment for general-purpose tractors will be the same; yet strength and rigidity need to be greater, and of course detail design will vary.

The result to be aimed at in the design of cultivating equipment for general-purpose tractors is that of cultivating the various row crops more thoroughly, easier, at less expense and with more power than can be done by older methods. This, then, classifies the requirements of design under four broad headings as follows:

1. Width of rows and crops to be cultivated
2. Quality of work done
3. Ease of handling
4. Economy

Width of Rows and Crops. Crop rows at present vary in width not only as to the locality where produced, but as to individual crops. It may be said that row widths are practically confined between 22-inch and 48-inch limits.

A difficulty, well recognized in horse-drawn cultivator design, at once presents itself. No one wheel tread can be found permitting the tractor wheels always to run

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[1]Paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, Chicago, December 1929.

[2]Manager, experimental department, Deere & Company. Mem. A.S.A.E.

between the rows for any such variety of row widths. One tractor can be made to give some latitude as to row widths. On the narrower rows more rows can be straddled, and also wheel equipment can be made reversible and wheels giving different wheel treads can be substituted. So, for example, one tractor can straddle two 36-inch or 38-inch rows, and also an extra one when it comes to some of the rows below 30 inches in width.

However, it will soon be necessary, for successful motor cultivation, to have some standardization established for row widths for the various crops. Corn is now largely planted in 42-inch rows. It would be desirable if this could be a standard width for corn. The possible exception to this might be in the South where cotton is grown mostly in 36 and 38-inch rows. There it might be that corn might be planted in the same width rows.

Potatoes are planted in varying widths of rows from 28 inches up to 42 inches. One tractor cannot cultivate all the different widths between these limits, and it would seem as though 34-inch or 36-inch rows would be preferable for potatoes.

Quality of Work Done. It is certain that, when the farmer adopts motor cultivation, he will not be satisfied with work inferior to what he has been used to formerly. As a matter of fact, there is no reason why cultivation by mechanical power cannot be done more thoroughly and better than it is possible to do with horse-drawn cultivators.

To bring about this desired quality of work, there are certain essentials the designer must keep in mind. They are:

1. There should be sufficient flexibility in the cultivating unit to allow all the shovels or sweeps to run at a uniform depth.

2. There should be sufficient rigidity in the structure to insure the shovels or sweeps staying down to their uniform depth even in hard ground.

3. The soil between the plant rows should not be left packed down. Wheel tracks have been eliminated in some cases by loosening the soil behind the drivewheels.

4. There should be sufficient dodge to keep the shovels running centrally in relation to the rows. In crossing checked rows, more dodge is necessary than in following drilled rows.

5. A depth control for shovels must be provided and also a means for adjusting the spacing of the shovels with relation to the row.

6. There must be a minimum of the crop plant knocked down at the ends of the rows in turning. This necessitates a short, quick turn.

7. There must be sufficient crop clearance in the design of both tractor and cultivating equipment to permit the proper laying-by of the crop without damage. In this connection it is worth noting that the condition of moisture in the crop has a more pronounced effect on breaking of the stalks of the plant than has the clearance. When corn is wet with dew, or after a rain, it is brittle, while when dry it can be safely bent to a greater degree than was customary in horse-drawn cultivator practice. In horse-drawn cultivator practice often the singletrees were placed so low and so nearly overlapped when the gangs were set in that the clearance of the horse-drawn outfit was sometimes nearly cut in two. This matter of clearance is primarily one of tractor design and the cultivating equipment must conform.

Ease of Handling. It is obvious that one man must accomplish the dual operation of driving the tractor and cultivating. The easier and simpler it is to operate the outfit, the more acres can be cultivated per day. Ease of operation may be promoted by the designer by:

1. Adding as little as possible to the duties of the operator. This means making the operation of the cultivator as easy and simple as may be.

2. Keeping the line of vision from the operator to the row as clear of obstruction as possible. Any obstruction is tiring to the eyes of the operator and will impair his efficiency.

3. Making it easy to get the gangs out of the ground at the ends of the rows, turn around on a small radius and drop the gangs in again.

4. Providing for strength enough in the cultivator to withstand accidental encounters with fence posts and other obstructions. Horse-drawn equipment will not be found to have sufficient strength. Loss of time occasioned by breakage or slippage of parts subtracts from the efficiency of the machine.

5. Designing the cultivating unit so it can be easily attached and detached from the tractor. During the cultivating season there will be other uses for the tractor and delays occasioned by time taken in attaching and detaching will be costly. In factory parlance, this would be called "indirect" labor. That which produces is "direct" labor. In other words as nearly 100 per cent as possible of the operator's labor must be expended on producing the crop.

Fall plowing with a general-purpose tractor and a 20-inch bottom fitted with a 33-inch rolling coulter. The outfit is shown plowing 8 to 9 inches deep in heavy bottom soil and turning under a rank growth of soybeans and corn which has previously been disked down

Economy. It may fairly be stated that if the design successfully meets the requirements previously outlined, the requirements of economy will have been anticipated. To be a sound proposition economically, the cultivating equipment for the general-purpose tractor must make it possible to cultivate row crops satisfactorily, and at a lower cost per acre than by older methods. This, of course, contemplates results and costs arrived at through accurate accounting.

Briefly the requisites for economy are:

1. A one-man outfit; economy forbids one man on the tractor and another on the cultivator.

2. Strength and engineering sufficient to permit continuous operation with a minimum of time lost due to delay.

3. Ease of handling, permitting high acreage capacity.

CONCLUSIONS

This subject is capable of being handled in many ways. It is a big subject; it is a live subject. It is one on which much work is being done, and on which more work will be done. The end is not in sight.

It would seem that the function of this Society in relation to subjects of this nature is to analyze them, and endeavor to outline results to be striven for, rather than methods of accomplishing them. Therefore, fundamentals must be considered rather than details. It is for the designer to determine how best to produce the structure that will give the results desired.

Organization of Research in the Adaptation of the General-Purpose Tractor[1]

By R. W. Trullinger[2]

A PROJECT of research in any feature of mechanical farm equipment, such as the general-purpose tractor, usually requires a considerable expenditure of funds and of the time of personnel. It is therefore an investment, and, as such, involves a risk. The prospect it has of returning dividends will depend primarily upon the degree to which it is sound, practical and conservative. This in turn will depend upon the investigator, his scientific attitude, the depth of his purpose, and the conception he has of the problem and its requirements.

A project on the development of the tractor to adapt it to the requirements of general-purpose farming ought to commend itself in the prospect of results, as well as in the desirability of the information sought. Such a project cannot return a dividend of information of permanent value unless it is properly organized to do so. If it cannot stand the test of searching scrutiny in this regard, it is likely to be an undue risk.

There is probably no field of scientific endeavor in which the opportunity is greater for wasteful and misdirected effort than in that of research in mechanical farm equipment, and the tractor appears to be no exception in this regard. Numerous scrap piles of junked iron and the red ink of untold expenditures speak eloquently of lack of vision, inadequate fundamental conceptions, and lack of consideration for specific requirements in past undertakings of this character.

In the earlier days of experimenting with tractors the problem, as a whole, seemed simple and capable of solution by a few field trials and routine engineering computations. Further work showed, however, that the matter was considerably more complex than it appeared originally, and that investigations consisting solely of field tests of mechanical ideas, without the aid of further technical and scientific refinements in procedure, inevitably produced results of no finality. Now that the general-purpose tractor has appeared on the scene, the necessity for practically a new beginning with a revised vision, an improved technic, and a more detailed knowledge of requirements is apparent.

It is not the purpose to disparage elementary and practical investigations of tractors, for general testing and comparative field trials are the necessary preliminaries to better things, if they are considered as such. Without doubt there is frequently a place and a need for simple tests of tractors in the general-purpose class which are exploratory and designed to meet temporary requirements, but these should not be considered the means to an end. Such tests are not research in a true sense, and engineering investigators cannot afford at this pressing stage to exhaust themselves and their resources by such efforts, and thereby fail to get deeper into the real problems involved in general-purpose tractor development when opportunity is offered.

The research worker in farm tractors should be more than a mechanician, a tester, or a technical adviser. His work should be creative and should seek permanent values. If his work ever comes into general use, it will be because he has developed some basic facts which can be used intelligently and modified as circumstances require. What is known of the principles of traction in soils and of the design of tractor wheel equipment, for example, are basic facts of a permanent and generally applicable character. Such basic facts have resulted from research efforts aimed at the solution of a limited and concrete, but pertinent question. These researches have been based upon a clarified vision, a sound technic, and a profound knowledge

[1]Paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, Chicago, December 1929.

[2]Assistant in experiment station adminstration (senior agricultural engineer), Office of Experiment Stations, U. S. Department of Agriculture. Mem. A.S.A.E.

"Successful research in the development of the tractor along general-purpose lines will depend to a large extent, not only on the advance of known engineering and agromomic principles, but on the advance of such related sciences as physics, physical chemistry, metallurgy, soil technology, and the like . . . Thus a knowledge of the progress of physical and biological sciences may make attainment in tractor development more possible, and hence the importance of breadth of vision and interest when investigating such a complex field"

of certain specific requirements of power operations in agriculture.

The investigator ought therefore to have, as a background, a clear conception of the general-purpose tractor, what in general it should accomplish, and the limits of the conditions to which it is adapted. In this connection it appears that the numerous conceptions of the general-purpose tractor vary in some respects and agree in others. The important points of agreement indicate that the general-purpose tractor should be a simple, compact, relatively light-weight machine which is adapted primarily to the cultivation of certain major row crops, but which also will satisfactorily perform the usual tractor work of plowing and driving belted machinery. It should combine economic advantage with practical utility and be manufactured profitably by modern mass production methods. The concensus of opinion also seems to limit the general-purpose tractor largely to the two-plow type of about 10-20 horsepower rating, with a maximum weight of about 3,000 pounds.

The sphere of economic and practical utility of the general-purpose tractor in farming seems also quite definitely limited to medium-sized diversified farms of from 160 to perhaps 300 acres, growing one and, at the most, two major row crops, and on which the horse labor can be reduced appreciably by tractor cultivation of the row crops, and the efficiency of the man labor be increased to a maximum thereby. The number of hours of farm use annually of the general-purpose tractor also seems to have a rather definite economical and practical minimum of about 300, according to information reported by several public and private research agencies. In addition, it seems desirable to utilize the general-purpose tractor in pressing seasons as nearly 24 hours a day as possible.

With the above broad conception of the general-purpose tractor and its sphere of usefulness, the investigator should clarify his mind as to what he is seeking and just why he is seeking it. He may be concerned with the improvement of a specific feature of an existing tractor or the development of an entirely new feature to meet an established requirement, but his attitude should be the same. He should have clearly in mind the character, requirements, and surroundings of each specific detail to which he proposes to devote attention, and should understand thoroughly the part which each such detail will contribute ultimately to the economic and practical utility of the tractor in general-purpose farming.

It seems right to expect at this stage then that the investigator will consider the general-purpose tractor, not as one big problem, but primarily as a combination of several problems. Each of these problems will be the subject of a definite and limited study in the order of its relative importance. As such, it should form an important integral part of a program of similar researches on the tractor which eventually will be coordinated into a broad basis for theory and practice in the design of tractors of the general-purpose class.

Thoughtful planning of such research will include also a consideration of the background of such empirical facts and information as are already available. Even though the research program under consideration proposes to establish new facts about specific features of the general-purpose tractor, such for example as steering, traction, or lateral stability, the conception of its logical organization lies in what already has been accomplished and especially in what definite things of a limited character this suggests.

In this connection much has been done by the agricultural experiment stations, the farm equipment manufacturers, and other public and private agencies to establish a background of empirical facts and information relating to the requirements of the tractor for general-purpose farming. Blind speculation is no longer necessary in the majority of instances to permit greater concentration of the objectives in research and the better formulation of the necessary ideas back of the development of features of the tractor to adapt it to the requirements of general-purpose farming.

It is recognized especially that the primary requirements of this machine are based upon its ability to perform the tillage, cultivation, and other power operations involved in the production of certain major row crops such as corn, cotton, and potatoes. Considerable field testing has been done with existing tractors on these crops to determine the degree of their present usefulness and to identify their deficiencies. The results of these tests point to numerous important individual features meriting separate, specific, and fundamental inquiry.

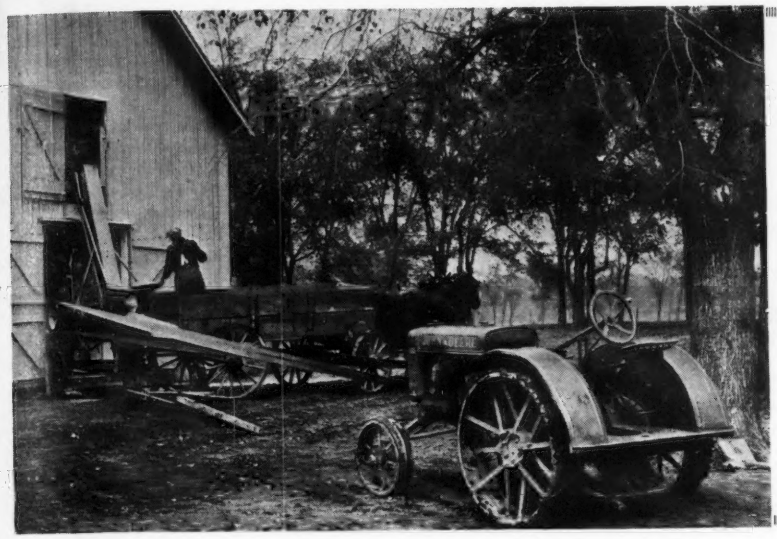
These features include the design of steering gear, and drive and guide wheels and their equipment, traction and draft ability and efficiency, manner of power application, lateral and longitudinal stability, lateral and vertical clearance, design of hitches and implement attachments, overall lubrication, the efficiency of engine fuels and carburetion, air cleaning, engine cooling, and numerous other definite features. Each of these features contributes in its peculiar manner to the ability of the tractor to meet economically the established requirements of the crops concerned for tillage, cultivation, spraying, harvesting, and the like, under the range of soil, climatic and other conditions encountered in this type of farming, and the nature of such contribution should be thoroughly understood.

Each feature mentioned also has a background of empirical information upon which sound productive research can be built. For example, a study of the most economical and practical manner of power application by the general-purpose tractor to the different operations involved in row crop production, would include a consideration of power take-off and the like, regarding which considerable of a practical nature is already known. It has been shown that under favorable conditions only about half of the motor power of a tractor is delivered to the drawbar, and under unfavorable conditions this delivery is frequently reduced to as low as 25 per cent. It thus appears that the development of efficiency in the application of power must of necessity attach to specific operations and implements.

It also has been pointed out by public and private research agencies that the tractor has a low thermal efficiency. There has been much experimenting with fuels and motor lubrication in connection with the performance of definite power operations by the tractor which should serve as bases for specific fundamental researches of an important character.

The wide variations in soil types, especially in their tractive properties, has been the occasion for considerable experimenting with drive and guide wheel and hitch equipment. These have eliminated many theories and have tended to narrow the matter down to certain pertinent lines of inquiry. Experiments with horizontal clearance appear to have pointed to the necessity of clearing two or three rows of a major crop to permit the cultivation of at least four rows, thus defining the limits of development of this feature of the general-purpose tractor to meet the requirements of rather well-established agronomic practices.

It would appear further that each instance of such research on features of the general-purpose tractor should be attached to a rather definite system and size of diversified farming and to a limited number of agronomic practices. It is hardly conceivable, in fact, that research of this character can be applied effectively to more than one set of conditions at a time. For example, some of the experiment stations have attempted to strike an average for vertical clearance of the general-purpose tractor to cover the requirements of major row crops generally. However, an analysis of the situation reveals numerous points of variation among row crops such as corn, cotton, pota-



"The research worker in tractors must cultivate originality and an inquiring and critically analytical frame of mind. He may be fortified by a vast and profound knowledge of science and technology, but unless he has developed a frame of mind which is capable of a systematic analysis and orderly synthesis of the elements of such a complex problem as that offered by the tractor, he is likely to become an assistant in such research instead of becoming the leader"

toes, sorghum, and the like, which are inherent in the several established agronomic practices for their optimum production. Since the primary purpose of this research is to adapt the tractor to the requirements of the cropping practice, so far as is possible and practicable, and not vice versa, this would point to the necessity for considering the requirements of the crops individually in this connection.

It would appear also that each instance of such tractor research should be governed in its fundamental scientific aspects by the requirements of the specific operations involved in the production of the basic major row crop concerned. Preferably each separate inquiry should be aimed at settling one specific point in question, such for example as steering or traction in cultivation, seeking to establish permanent basic values and principles of general applicability which can be used intelligently and profitably in tractor design and modified as the circumstances of general-purpose service require. The findings of several such specific inquires should be calculated to blend into a practical understanding of these facts and a knowledge of their relationships, in the aggregate, establishing definite progress in the development and adaptation of the tractor to the different important features of general-purpose farming.

The organization of the procedure of a project of research on some specific feature of the general-purpose tractor should indicate at the outset the general line of attack and the technic and equipment to be employed. Naturally the details of procedure will be subject to revision from time to time, as the course of investigation depends on the progress results and what they indicate. Ascertaining what data are essential in solving the particular problem in hand, and devising means of securing them and testing them as to their adequacy and applicability are, therefore, important features in the organization of such research. Past experience has shown that these features include controlled laboratory researches, as well as verifying field tests. In recognition of this, several of the experiment stations have set up research equipment designed to isolate and control such specific features of the tractor as traction, lubrication, equilibrium, steering, and the like. Some foreign research institutions have likewise recognized the necessity at this stage of more profound studies of the tractor in its several details, and the Technical Agricultural Academy of Berlin, for example, has set up a laboratory for isolating and studying some of these details under controlled conditions. In fact, it appears that the basis of all such research on the tractor is the accumulation of evidence and its method of procedure is the means by which the needed evidence is secured. Therefore, the aim in each case should be, naturally, to so organize the procedure as to secure evidence that concerns the specific point at issue, that is as positive as possible, and is sufficiently extensive to enable critical analysis.

It is also essential therefore that the technical details of each problem under study be understood as fully as possible at the outset on the basis of what has gone before, and be developed as the work progresses. In tractor studies to meet general-purpose farming requirements there is, in fact, already some basis in the researches of others for judging the technical and scientific nature and content of certain problems at the time of organization. For example, the available knowledge of the fundamental physical principles of traction in certain types of soils would be pertinent to a study aimed at the development of general-purpose tractor drivewheels adapted to seedbed preparation and cultivation for corn on one of these soil types. Similarly the knowledge of the physical principles governing the movement of abrasive dusts in moving air currents would be pertinent to the study of air cleaning and lubrication in the adaptation of a general-purpose tractor motor to the cultivation of a crop in dusty regions. The available knowledge of the physical and mechanical properties of special metals such as high strength, lightweight alloys, for example, may have considerable application in the development of tractor parts, which are subject to sudden heavy stresses, in attempts to adapt the general-purpose tractor to severe conditions of service such, for example, as plowing in the stony soils of Pennsylvania. All such previous technical evidence of a nature pertinent to the specific inquiry in progress may contribute in considerable measure to the solution of the problem, and therefore should be thoroughly mastered at the outset.

In this connection it is evident that successful research in the development of the tractor along general-purpose lines will depend to a large extent, not only on the advance of known engineering and agronomic principles, but on the advance of such related sciences as physics, physical chemistry, metallurgy, soil technology, and the like. In this as in other lines of inquiry regard must be had for the inevitable sequence in research necessary to unravel a problem. Results have sometimes been sought in such work which are unattainable because some branch of science essential to their solution has not been taken into account

or has not produced the knowledge or supplied the ideas on which a working hypothesis could be framed. It will be recalled, for example, that an understanding of the elements of slippage in traction on certain soils and its correction waited a long time on the development of that feature of soil technology relating to the dynamics of stress distribution in those soils under tractive impulses.

Thus a knowledge of the progress of physical and biological sciences may make attainment in tractor development more possible, and hence the importance of breadth of vision and interest when investigating such a complex field. Advanced training in some of these related sciences for the agricultural engineer may be just what is needed to develop his imagination or expand his range of thinking. At least such broadening, stimulating influence promotes cooperation and coordination where desirable. It makes more apparent the advantage of greater system in tractor research and the logical following out of certain lines of advance through the various specialties involved.

In this connection the broad conception of the general-purpose tractor and its sphere of usefulness in farming would indicate that the organization and prosecution of research in its development are not functions of the agricultural engineer alone, but also will draw in the agricultural economist and agronomist on a close cooperative basis. It seems important at the outset, therefore, that full consideration be given the specific responsibilities of these three agricultural specialties in attaining the desired objective for the purpose of their effective coordination. This implies the arrangement of the engineering features of such research in relation to the economic and agronomic features, either through coordination or conscious participation in organized efforts to solve each particular problem involved in the development and rapid advancement of tractor knowledge.

With due appreciation of the advantage of specialization, it is apparent that the research specialist in mechanical farm equipment cannot afford to conceive his specialty too narrowly or limit his collateral interests too closely. Whether he is working on its problems independently or in cooperation, his work needs to be coordinated with other branches and features of agriculture which may be equally essential, and these considered in their respective relationships to complex problems such as those offered by the general-purpose tractor.

In addition, the research worker in tractors must cultivate originality and an inquiring and critically analytical frame of mind. He may be fortified by a vast and profound knowledge of science and technology, but unless he has developed a frame of mind which is capable of a systematic analysis and orderly synthesis of the elements of such a complex problem as that offered by the tractor, he is likely to become an assistant in such research instead of becoming the leader. The ability to think and reason in a systematic, orderly, and original manner, to analyze a problem into its essential features, and to apply scientific and technical knowledge where it will do the most good, eventually arriving at something definite and worth while about a specific thing, marks the distinction between the leader and the trailer in research in mechanical farm equipment.

Controlling the Cotton Boll Weevil

By D. Victor Stapleton[1]

LITERALLY hundreds of mechanical devices for controlling the cotton boll weevil have been manufactured during the past few years. None of these have been successful, at least none have survived. As a result of the number of failures a question as to whether or not boll weevils can be controlled by a mechanical device has arisen. The illustrations show the invention of a Mississippi farmer. In a number of tests in Mississippi over a period of three seasons it has proven successful.

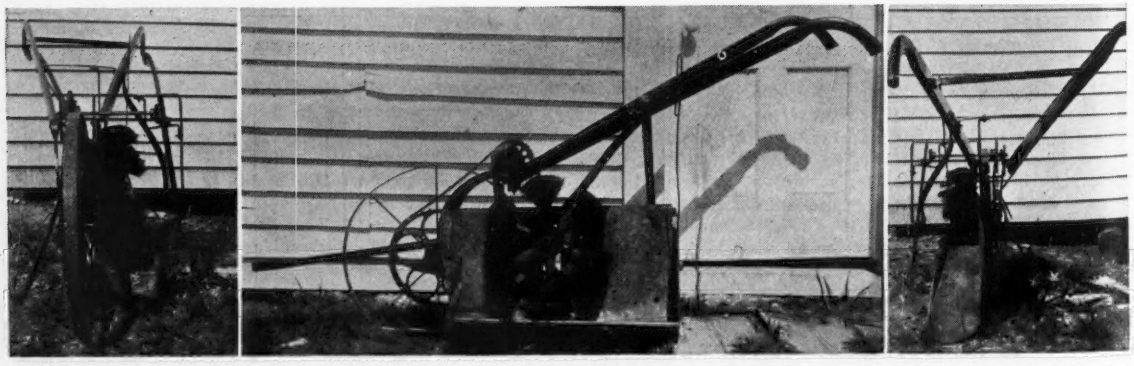
On June 18, 1929, a total of 180 boll weevils per acre were caught with this machine on the Mississippi Agricultural Experiment Station cotton plots by running it over the cotton only once. The infestation at that time was less than 5 per cent.

On July 5, 1929, a careful and authentic count revealed 57 boll weevils on an acre of large cotton. The boll weevil exterminator was run over it once by a negro and caught 40 of these weevils, or approximately 70 per cent. This cotton was too large for the machine, and it is reasonable to believe that a higher catch would have been made under more favorable conditions. A number of other tests were conducted in different fields, and in one case, under favorable conditions, it was estimated that 81 per cent of the boll weevils on a plot were caught with the machine.

It is generally believed among agricultural workers and agricultural engineers that not more than two or three applications should ever be necessary in one season. The machine is light, simple, small and easy to handle. It is designed for small cotton, although good results have been secured in large cotton.

The device is not yet on the market, but it will be low in cost and is expected to be a boon to cotton growers, particularly in the older cotton states of the Southeast. Sufficient patents have been taken out to amply protect the invention.

[1]Former supervisor of vocational education, State of Mississippi.



Front, side and rear views of the cotton boll weevil collector

California Rice Land Seeded by Airplane[1]

By E. N. Bates[1]

THE Crocker-Huffman Land and Water Company of Merced, California, found early in May, 1929, that flocks of migratory mudhens had almost completely destroyed the seeding on one section of their rice land. In California a common custom is to broadcast the seed on the dry land and flood immediately. This land had been seeded and flooded, and to drain and reseed the area in the customary manner so late in the season was practically impossible. The results of some government experiments on seeding rice on top of the water suggested a possible solution of the problem[2].

E. S. Murchie, assistant manager, and T. R. McSwain, the land and water engineer for the company, after considering different methods of seeding in the water finally decided to try the rather unique experiment of scattering the seed over the affected section from an airplane. They enlisted the services of their local commercial airport proprietors, Frank Gallison and L. F. Tedrow.

The plane selected for the experiment was a long-wing Eaglerock biplane designated as OX5. The forward cockpit was lined with canvas to hold the rice and provided with two hoppered outlets. It was decided that the plane could safely fly with 500 pounds of rice loaded into this improvised grain hopper. The normal speed of the plane was 70 miles an hour.

To give an even seeding, it was decided to first sow the rice on the area at one-half of the desired rate of seeding in one direction, and then sow the other half in a second covering of the field with the plane flying at right angles to the first direction of seeding. By experiment the two openings in the hoppered cockpit, through which the seed rice was allowed to flow, were adjusted so the 500 pounds of rice would be discharged in approximately one minute, the time necessary to fly across the field.

To seed 500 pounds of rice in a trip across the section to one-half the seed thickness desired would require that 62½ pounds of rice be seeded per acre, which meant that 500 pounds would seed eight acres, or a strip 66 feet wide across the field. The field was therefore, surveyed in checker-board style with the lines 66 feet apart each way. By experiment it was then found that the rice flowing out of the hopper into the air blast from the airplane propeller was spread out quite evenly into a stream that was approximately 66 feet wide when the plane flew at about 200 feet above the ground. Those who saw the seed fall on the water said they thought the distribution was more even than could have been obtained by any other method.

The plane required about 2,000 feet of runway to lift its load of 500 pounds of seed. A temporary airport 2400 feet long was built near the rice field by use of two scrapers drawn by tractors. The seed rice was hauled to the airport in bags and piled near the take-off end of the runway.

In operation the plane required ten minutes to make a round trip. Five minutes were required to load the plane, and five minutes to make the five-mile course across the field and back to the landing point. The painted signals of four flagmen stationed on the surveyed lines across the field guided the plane in its course. Each time the plane flew across the field the flagmen moved their signal posts over 66 feet to the next line.

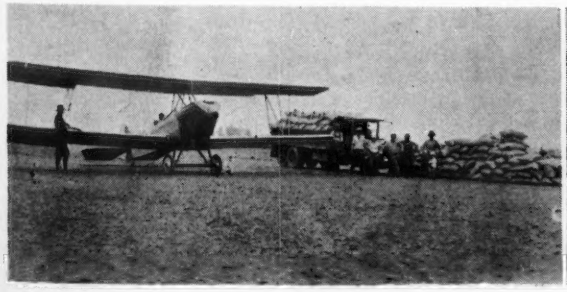
In the three days required to seed the section, the plane made 160 trips, traveling 800 miles and seeding 800 sacks, or 40 tons of rice.

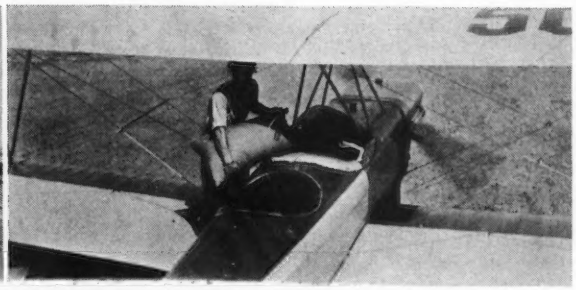
The costs were as follows:

Surveying the flag lines	$ 52.15
Building the runway for the plane	173.90
Four flagmen three days at $4.00 a day	48.00
Labor loading the airplane	48.50
Airplane hire—24 hr. at $27.00 an hr.	648.00
Insurance on plane and pilot	288.00
Total per section	$1258.55
Cost per acre	$1.97

The cost of $1.97 per acre is recognized as being too high to interest the rice farmers as a means of seeding under ordinary conditions. We are informed, however, that in the future the Merced pilots will not require the plane and pilot insurance. This would reduce the per acre cost to $1.52. It is very apparent that even this cost can be considerably reduced by studying the problem. However, in an emergency such as the case here recorded, this rather high cost would probably not be an objection.

Early in the growing season Mr. Murchie said the rice on this section appeared to be in excellent condition



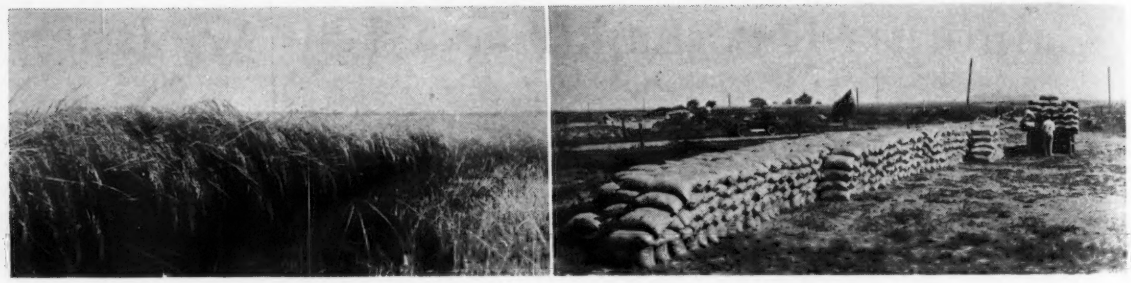


(Left) An 8-ton motor truck hauled the seed rice to the airport. The Eaglerock biplane used in the airplane rice seeding experiment by the Crocker-Huffman Land and Water Company, is shown in this picture. (Right) The front cockpit of the plane was lined with canvas and made into a bin holding 500 pounds of rice. The rice was discharged below through two spouts into the propeller blast

[1] In charge of Pacific Coast office of rice and grain investigations, U. S. Department of Agriculture. Mem. A.S.A.E.

[2] Jenkins W. Jones, in charge of the U S. Department of Agriculture Rice Experiment Station, at Biggs, California, has released the information that tests which he had conducted showed that rice seed sown in the water after the field is flooded, germinates better than it does if the seed is covered with earth and then flooded. His tests showed that 85 per cent of the rice sown in the water germinated, while only 25 per cent of the rice planted one-half inch deep, and only 4 per cent of the rice planted one inch deep germinated when flooded immediately after seeding.

[3] The standard rice sack holds approximately 2¼ bushels of grain.



(Left) This picture shows the heavy stand of rice on the section of land seeded by airplane. (Right) This is part of the 35,000 bushels of rough rice harvested from the section of land seeded by airplane

and was catching up rapidly with the original planting in adjoining fields which were sown in the regular manner.

Mr. Murchie in a letter dated November 6, 1929, stated: "We have just completed the harvest on the section of land seeded by airplane. The average for the whole field was twenty-five sacks to the acre with portions of the land running as high as forty sacks[2] to the acre. The soil in this piece of land is considerably below the average quality in our rice area and we feel well satisfied with the yield obtained."

It is interesting to note that the average yield of rough rice for the last five years for the United States has been 40.7 bushels per acre. The average yield of rough rice for the last five years for California has been 53.1 bushels per acre.

The section seeded by plane yielded on an average of 56 bushels per acre, which is 15 bushels per acre more than the average for the whole United States and about three bushels per acre better than the average for California for the past five years.

Mr. Murchie suggests the following possible advantages of sowing rice by airplane:

1. "Land can be prepared and water set ahead of normal planting time, thus permitting the water to warm up and prevent frost in early sowing.
2. "On alkali land an early flushing can be made before seeding time.
2. "On alkali land an early flushing can be made beset ahead of seeding time to control the watergrass.
4. "Oftentimes a rain delays the planting of rice by any other method until land dries.
5. "Where irrigation water is not available for quick initial watering, but sufficient for carrying the crop after land is covered, the watering can be started ahead of seeding time so as not to delay the crop.
6. "Speed, which may save several weeks at harvest time and save many thousands of dollars in harvesting the crop.
7. "In cases where original sowing is lost from any cause this is the only practical method of resowing a large area without draining water and waiting for land to dry."

It would appear that the Crocker-Huffman Land and Water Company considers the experiment successful and that airplanes, at least for emergency seeding of rice, are feasible in California.

Clean Seeds and a Clean Field

NO ONE knowingly pollutes his own well, but there are still thousands of farmers seemingly but little concerned at sowing noxious weed seeds on their fields. Just as it is easier to screen out flies and mosquitoes than to keep the swatter busy, farmers find it more profitable to reclean their seeds than to spend many anxious hours trying to kill weeds already introduced. Destroying the enemy beyond the front line has always been found to be more efficient than inviting him into the trench for a hand to hand conflict.

Harvesting a weedy crop of wheat or oats has always required more labor and expense but with the more general use of the combine the handicap imposed by weeds has been even more noticeable. With a wet season last spring, the weeds got an extra fine start and in many sections the use of the windrower was necessary where straight combining would have been satisfactory in a clean field.

The combination screen shaker and wind fanning mill, which is used largely for oats and barley will often pay for itself in a single season because of the larger yields made possible by the elimination of light grains and weed seeds.

Wheat farmers, who are receiving increasing penalties each year from dockage and lower yields, will find seed cleaning of foremost importance in their war against weeds. They may choose one of the newer disk separators or a cleaner of the aspirator type. The former is made up of a number of flat disks which have pockets for different weed seeds and foreign grains but not for wheat. Portable machines of this type are also used in connection with threshing machines. The aspirator type of recleaner operates by allowing a thin film of grain to fall in front of a wind blast which separates the heavy wheat from the lighter kernels and other dockage.

Harrow, Plant, and Cover at One Time

FARMERS who have only small acreages of land to seed to alfalfa or grass, or who prefer to drop the seed and then harrow it under, should find the harrow seeder an inexpensive and simple tool.

This machine consists of a seeder box which is carried on low wheels. The harrow is attached at the rear, just as though the seeder were an evener, and covers the seed immediately. The principle is the same as attaching a smoothing harrow behind an ordinary broadcast seeder.

Efficient hook-ups for tractors may be devised with either harrow seeders or broadcast seeders, by using a disk harrow or pulverizer next to the drawbar, then the seeder, and a drag harrow attached at the rear. This is a satisfactory and quick method of planting small seeded legumes and grasses.

Heat Transfer in Dairy Machinery[1]

By John T. Bowen[2]

(Concluded from the January number)

Surface Cooler. The surface cooler is a modified form of the counter-current type, and for practical purposes may be considered as such. In this type of cooler the hot milk is caused to flow down over a corrugated metallic surface, where it is exposed to the air; on the other side of the metal surface cold water, or brine, is passed.

The hot milk flows down over the corrugated surface at varying velocities, depending on the smoothness of the surface, the height of flow, the quantity of liquid flowing and the thickness or viscosity of the liquid. The cooling medium enters at the bottom, circulates back and forth and leaves at the top. The velocity of the cooling medium is a very important factor in the rate of cooling. A velocity of about 150 feet per minute gives satisfactory results in this type of apparatus. Since the milk over the surface cooler is spread out in a thin layer, the transfer of heat is rapid. In addition to the absorption of heat by the circulating cooling medium, the air absorbs heat which is manifested in a rise in the temperature of the air and in evaporation. The quantity of heat absorbed by the air depends upon the temperature of the air in contact with the liquid, its original moisture content and the rate at which it passes over the hot liquid. With natural circulation the air rises over the surface of the warm milk at a velocity around 3 feet per second under average conditions. The loss by evaporation is often an item of considerable importance as it may, and sometimes does, reach 3 per cent with natural circulation under favorable conditions and considerably more in the case of forced circulation.

Assuming an evaporation of 3 per cent, then if 5,000 pounds of milk are cooled the loss will be 150 pounds, which at $2.50 per hundred pounds is $3.75. Under these conditions approximately 30 per cent of the cooling is accomplished through evaporation.

A test on a surface cooler having 43 square feet of cooling surface was made by the writer, using the cooler as a regenerator. The arrangement was such (See Fig. 11) that the hot milk from the pasteurizer entered the tubes at the bottom and passed up and out at the top, while the cold milk flowed down and over the outer surface and was caught in the trough from which it entered the pasteurizer. The pasteurizer was located close to the cooler, hence the radiation losses from pipes connecting the pasteurizer and cooler was small and may be ignored. The flow being constant and continuous, the quantity passing over the outer surface and that through the tubes was equal. Therefore, if there were no losses the heat absorbed by the milk passing over the outer surface must equal that given up by the milk passing through the tubes. The following data were taken on test:

Area of cooler surface	43 sq. ft.
Rate of flow of milk per hour	3,255 pounds
Initial temperature of cold milk	64.66 degrees
Temperature of milk entering pasteurizer	136 dgrees
Temperature of milk leaving pasteurizer	162 degrees
Temperature of milk leaving regenerator	93 degrees

The quantity of heat given up by the milk inside the tubes was $Q=3,255x0.93\ (162—90)=217,945$ B.t.u.

The quantity of heat absorbed by the milk in passing over the outer surface was $Q_1=3,255x0.93\ (136—64.66)=215,956$ B.t.u., a difference of 1,999 B.t.u. This loss is obviously due to the aeration of the milk and amounts in this case to approximately one per cent. The air conditions were not determined during the test, but there was considerable escaping steam in proximity of the apparatus and hence the relative humidity was high.

The arithmetical mean temperature difference between the milk inside and ouside the tubes was

$$t_m=\frac{28.34+26}{2}=27.2 \text{ degrees}$$

The coefficient of heat transfer was

$$U=\frac{217,945}{43 \times 27.2}=186 \text{ B.t.u.}$$

The velocity of the milk inside the tubes was 56 feet per minute, and over the outer surface about 30 feet per minute. The low value of "U" is evidently due to the slow velocity of the liquid through the tubes.

Attention is here called to the great saving in heat by employing the regenerative, or heat-exchange principle. It will be noted that the total rise in the temperature of the milk was from 64.66 to 162 degrees and the total quantity of heat absorbed by the milk was $3,255x0.93\ (162—64.66)=294,663$ B.t.u. But $3,255x0.93\ (136—64.66)=215,947$ B.t.u. was exchanged from the hot milk leaving the pasteurizer to the cold incoming milk. Hence the pasteurizer is credited with furnishing only 294,663—215,947=78,716 B.t.u. or only $(78,716 \div 294,663)x100=26.7$ per cent.

Assuming that the milk was finally cooled to 40 degrees then the total quantity of heat taken out of the milk was $3,255x0.93\ (162—40)=369,312$ B.t.u. There was exchanged from the hot to the cold milk, $3,255x0.93\ (162—90)$—217,955 B.t.u., leaving only 369,294—217,944=151,357 B.t.u., or $(151,357 \div 369,312)x100=41.2$ per cent to be taken out of the milk by other means.

The total saving in heating and cooling, by the use of the regenerative principle, in this case amounts to $(433,891 \div 663,957)x100=65.3$ per cent.

Regenerators or Heat Exchangers. The function of a regenerator, or heat exchanger, is to economize heat by transferring it from the hot to the cold substance. The counter-current principle is usually employed and the regenerative features are so arranged that the hot milk leaving the pasteurizer gives up a portion of its heat to the incoming cold milk, thus raising the temperature of the incoming milk while that of the outgoing is lowered. Since the pasteurizing cycle consists in both raising and lowering the temperature of the milk, it is obvious that the regenerator, or heat exchanger, performs the double function of heating and cooling, thus economizing in both operations. The action of the regenerator is illustrated in Fig. 4. (See page 28, January issue of AGRICULTURAL ENGINEERING). The generative principle is applicable to both the "holder" and "flash" processes of pasteurizing. In the holder process the hot milk is transferred from the pasteurizer, or heater, to the holding vat where it is held for the required time. The hot milk is then caused to flow from the holding vat to the cooler through the regenerative apparatus, which is usually in the form of a double coil, having a smaller pipe inside of a larger one. The hot milk generally passes through the inner pipe, and the cold milk through the annular space between the inner and outer pipes. The milk entering the heater is thus preheated while that flowing to the cooler is partly cooled, the cooler proper reducing the temperature to the desired point.

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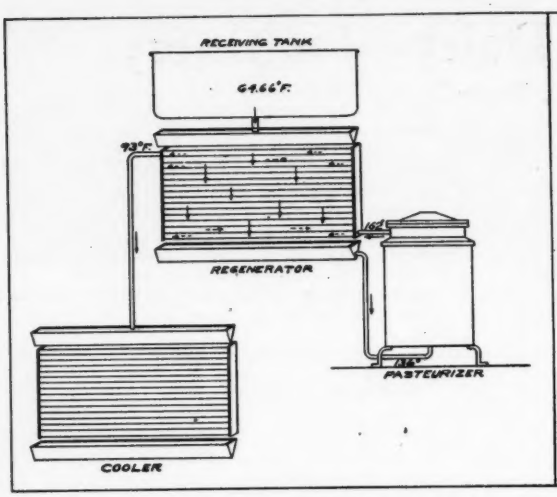
[1]Paper presented on the "Dairy Engineers' Day" program sponsored by the Committee on Dairy Engineering of the American Society of Agricultural Engineers, held in connection with the National Dairy Industries Exposition, at Toronto, October, 1929. (Concluded from the January number.)

[2]Senior electrical engineer, division of agricultural engineering, Bureau of Public Roads, U. S. Department of Agriculture.



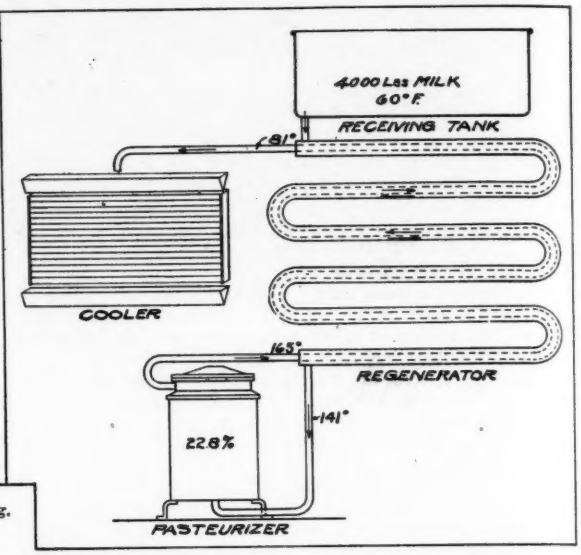


Fig. 11. (Above) Surface cooler used as a regenerator. Fig. 12. (Right) Diagram showing regenerator connections

In the flash process the hot milk flows directly from the heater through the regenerator to the cooler. In the flash type of pasteurizer the regenerative elements are often constructed inside the machine. It is obvious that any heat transferred from the hot to the cold milk represents just so much gain in economy.

By increasing the amount of heating surface in the regenerator, or heat exchanger, the hot and cold liquid can be brought to as near the same temperature as desired. But since the area of the heating surface increases very rapidly as the temperatures approach each other it is impracticable to heat the incoming cold milk closer than about 20 degrees to that of the hot. In other words, it is practicable to transfer about 75 per cent of the heat of the hot outgoing to the cold incoming milk, thus requiring the heater to furnish only about 25 per cent of the total heat needed. This means that, by employing a regenerator, only about one-fourth as much heat must be supplied by the heater as would be required if no regenerator was used.

While the regenerator is an efficient piece of apparatus from an engineering standpoint, it has its disadvantages from the bacteriological standpoint as it is difficult to clean and sterilize properly. In Fig. 12 the principle of the regenerator is illustrated.

In a test on this apparatus the following data were obtained:

Milk handled per hour	4,000 lbs.
Initial temperature of milk	60 degrees
Temperature of milk entering heater	141 degrees
Temperature of milk leaving heater	165 degrees
Temperature of milk leaving regenerator	81 degrees

The heat transfer in the regenerator was,

Heat absorbed by incoming milk=4,000x0.93 (141—60)= 301,320 B.t.u.

Heat given up by hot milk=4,000x0.93 (165—81)=312,480 B.t.u.

It is obvious that the heat given up by the hot milk must equal that absorbed by the cold milk, less radiation to surrounding air. Since the figures do not balance, the difference represents the heat radiated to the air, the ratio of their differences being the efficiency of the regenerator. The efficiency of the regenerator is, therefore, (301,320÷312,480)x100=96.4 per cent. The total rise in the temperature of the milk was 165—60=105 degrees, and the total quantity of heat supplied the milk was 4,000x 0.93x105=390,600 B.t.u.

Since 301,320 B.t.u. was transferred from the hot to the cold milk, the heat furnished by the pasteurizer was only 390,600—301,320=89,280 B.t.u., (89,280÷390,600)x100= 22.8 per cent of the total heat required to perform the work. In other words, the regenerator saved 77.2 per cent of the heat required to pasteurize the milk. The mean temperature difference between the cold incoming and the hot outgoing milk was

$$T_m = \frac{(165-141)-(81-60)}{\log_e \frac{165-141}{81-60}} = 22.9 \text{ degrees.}$$

Assuming the value of U as 200, then the area of heating or cooling surface required is,

$$A = \frac{301{,}320}{200 \times 22.9} = 65.8 \text{ square feet.}$$

Batch Heating and Cooling. The heating and cooling of milk in batches is largely practiced in the dairy industry. With this method the required quantity of milk is run into the vat and the heating, or cooling, medium is circulated through coils immersed in the liquid, or through a jacket which surrounds the vat, or in some instances through both jacket and coils. The modern batch pasteurizer, or cooler, is provided with a rotating coil through which the heating or cooling medium is circulated. The rotating coil serves to agitate the milk and hence the temperature of the milk at any instance is practically uniform throughout its volume.

The calculation of the transmission of heat in a vat provided with rotating coils through which the heating or cooling medium flows is more or less complicated.

Considering the coil vat as a heater, if water at a constant inlet temperature is passed through the rotating coil, the mean temperature difference between the milk and the hot water inside the coils decreases continuously, the hot water being cooled from its constant inlet temperature to a final outlet temperature which increases as the operation progresses. The general action is shown in Fig. 13.

In order to arrive at the mean temperature difference between the milk and hot water throughout the operation, the mean temperature difference between the cold milk and hot water is obtained at the beginning and again at the end of the operation. The mean temperature difference between the milk and water over the whole operation is found from these two, that is

$$T_m = \frac{t_{mb} - t_{me}}{\log_e \frac{t_{mb}}{t_{me}}}$$

where t_{mb} = mean temperature difference at the beginning
t_{me} = mean temperature difference at the end.

For example, 5,000 pounds of whole milk is heated in a coil vat from an initial temperature of 60 degrees to a final temperature of 145 degrees. The heating medium is hot water, the entrance temperature being constant at 160 degrees, and the outlet temperature increasing from 75 to 150 degrees.

$$t_{mb} = \frac{(160-60)-(160-75)}{\log_e \frac{160-60}{160-75}} = 95.5 \text{ degrees.}$$

$$t_{me} = \frac{(160-145)-(160-150)}{\log_e \frac{160-145}{160-150}} = 12.34 \text{ degrees.}$$

$$T_m = \frac{95.5-12.34}{\log_e \frac{95.5}{12.34}} = 40.6 \text{ degrees.}$$

The mean temperature of the milk,

$$T_m = \frac{145-60}{\log_e \frac{145}{60}} = 96.1 \text{ degrees.}$$

and the mean outlet temperature of the heating water $t_m = 96.1 + 40.6 = 136.7°$.

The mean drop in temperature of the heating water is 160.0—136.7=23.2 degrees.

Assuming a thermal efficiency of the vat of 95 per cent, the total quantity of heat absorbed by the milk and radiated is

$$\frac{5{,}000 \times 0.93\ (145-60)}{0.95} = 416{,}052 \text{ B.t.u.}$$

and since the heat given up by the water must equal that absorbed by the milk and radiated, then the pounds of water circulated is,

$$P = \frac{416{,}052}{23.2} = 17{,}933 \text{ pounds}$$

In practice the entrance temperature of the hot water is seldom, if ever, constant. The method of operation is to fill the vat with the cold milk and then circulate over and over a comparatively small quantity of water through the revolving coil, the water being heated by injecting steam directly into it just before it enters the coil. In this case, the temperature of the inlet water, the temperature of the outlet water and the temperature of the milk gradually rise throughout the operation.

The general action is shown in Fig. 14 taken from actual tests.

The mean temperature difference between the inlet and outlet water at the beginning of the operation was

$$t_m = \frac{120-90}{\log_e \frac{120}{90}} = 105.3 \text{ degrees}$$

and at the end

$$t_{m1} = \frac{183-151}{\log_e \frac{183}{151}} = 167.5 \text{ degrees.}$$

Then the mean temperature of the inlet and outlet water throughout the operation was

$$t_s = \frac{167.5-105.3}{\log_e \frac{167.5}{105.3}} = 134 \text{ degrees.}$$

The mean temperature of the milk throughout the operation was

$$t_m = \frac{146-84}{\log_e \frac{146}{84}} = 111.9 \text{ degrees.}$$

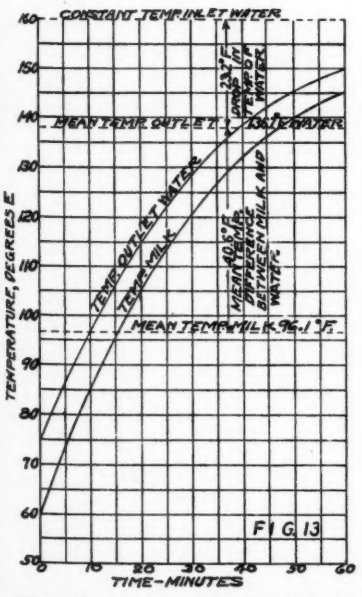
and the mean temperature difference between the inlet and outlet water and the milk was 134—111.9=22.1 degrees.

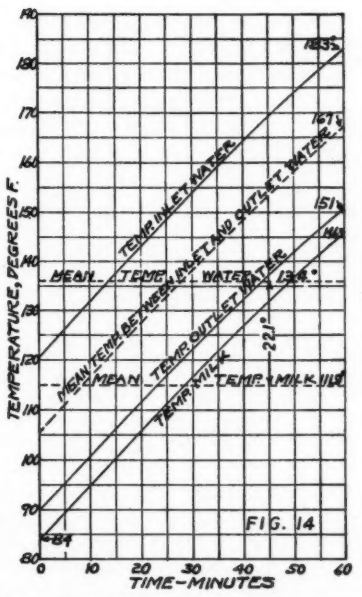
There was 5,061 pounds of skimmilk heated from an initial temperature of 84 degrees to a final temperature of 146 degrees, hence the heat absorbed by the milk was 5,061x0.96 (146—84)=301,231 B.t.u.

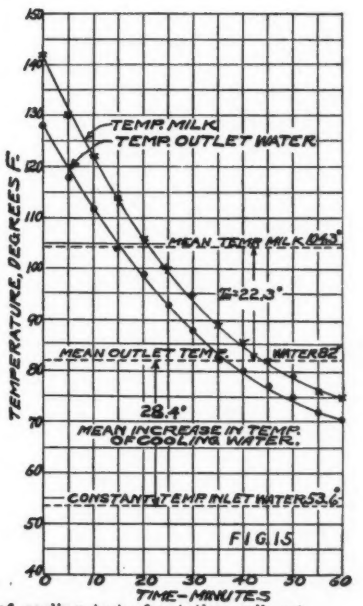
There was 10,880 pounds of water circulated. The mean temperature of the inlet water was

$$T_m = \frac{183-120}{\log_e \frac{151}{90}} = 154.1 \text{ degrees,}$$

and of the outlet water







Figs. 13 and 14. Results of heating test of rotating coil vat. Fig. 15. Results of cooling test of rotating coil vat

$$T_m=\frac{151-90}{\log_e\frac{151}{90}}=117.5 \text{ degrees.}$$

The mean temperature rise of the water was $t_m=154.1-117.5=36.6$ degrees and the heat given up by the water was $10,880 \times 36.6=398,208$ B.t.u. The efficiency of the vat was, therefore, $(301,231 \div 398,208) \times 100=75.6$ per cent. The heating surface of the vat was 65.5 square feet and the value of

$$U=\frac{301,231}{65.5 \times 26}=176 \text{ B.t.u.}$$

The velocity of flow of water through the revolving coil was 92.5 feet per minute.

A cooling test on the same vat was conducted and the following data taken:

Area of coil	65.5 sq. ft.
Amount of skimmilk cooled	5,061 pounds
Initial temperature of milk	142 degrees
Final temperature of milk	74½ degrees
Constant temperature of inlet water	53.6 degrees
Temperature of outlet water at beginning	128 degrees
Temperature of outlet water at end	70 degrees
Amount of water circulated	9,960 pounds

$$t_{mb}=\frac{(142-53.6)-(142-128)}{\log_e\frac{142-53.6}{142-128}}=40.3 \text{ degrees}$$

$$t_{me}=\frac{(74.5-53.6)-(74.5-70)}{\log_e\frac{74.5-53.6}{74.5-70}}=10.7 \text{ degrees.}$$

$$t_m=\frac{40.3-10.7}{\log_e\frac{40.3}{10.7}}=22.3 \text{ degrees.}$$

The mean temperature of the milk

$$\frac{142-74.5}{\log_e\frac{142}{74.5}}=104.3 \text{ degrees}$$

The mean outlet temperature of the water=104.3—22.3=82 degrees

The mean increase temperature of the cooling water=82—53.6=28.4 degrees.

Heat absorbed by the water=9,960x28.4=282,864 B.t.u.

Heat given up by milk=4,850x0.96 (142—74.5)=314,280 B.t.u.

Radiation and evaporation

$$\frac{314,280-282,864}{314,280}\times 100=10 \text{ per cent.}$$

$$U=\frac{282,864}{65.5 \times 22.3}=193 \text{ B.t.u.}$$

The results of the test are shown graphically in Fig. 15.

Heating Milk by Injecting Steam Into It. In many instances milk is heated by piping steam directly into it. This method is largely employed in preheating milk before condensing and in pasteurizing skimmilk for feeding to young stock. Many states have enacted laws compelling the heating of skimmilk to an average temperature of 178 degrees, or above when intended for feeding to young stock.

In case the steam is delivered directly into the liquid all the heat contained in the steam above the mean temperature of the milk is used for heating; consequently, each pound of steam discharged into the liquid delivers

$$L+T_m=\text{B.t.u.}$$

where L=latent heat in steam corresponding to the pressure

T_m=mean temperature difference between steam and milk. For example, dry saturated steam at 70 pounds gage pressure is discharged directly into a vat of milk, heating the milk from 60 to 178 degrees. The mean temperature difference between the milk and steam is

$$T_m=\frac{(316-60)-(316-178)}{\log_e\frac{316-60}{316-178}}=191.9 \text{ degrees.}$$

Then each pound of steam will deliver $897.2+191.9=1,089.1$ B.t.u. The pounds of steam required to heat a given quantity of milk through a stated temperature range can be calculated as follows:

$$P_s=\frac{P_m \times S_h\ (t-t_1)}{(L+T_m) \times E}$$

where P_s=pounds of steam required
P_m=pounds of milk to be heated
S_h=specific heat of milk
t=initial temperature of milk
t_1=final temperature of milk
L=latent heat of steam corresponding to pressure
T_m=mean temperature difference between steam and milk
E=efficiency of vat.

One thousand pounds of skimmilk having a specific heat 0.97 is heated in an open vat from an initial temperature of 70 degrees to a final temperature of 178 degrees, by injecting dry saturated steam at 70 pounds gage pressure directly into the milk. The efficiency of the vat is assumed to be 95 per cent.

The mean temperature difference between the steam and milk is

$$T_m=\frac{(316-70)-(316-178)}{\log_e\frac{316-70}{316-178}}=187.5 \text{ degrees.}$$

$$P_s=\frac{1,000 \times 0.97\ (178-70)}{(897.2+187.5)\ .95}=101.6 \text{ pounds}$$

The foregoing formula assumes dry saturated steam. If, however, the steam contains moisture, as is generally the case, the formula becomes

$$P_s=\frac{(P_m \times S_h)\ (t-t_1)}{(L \times q)\ (T_m \times E)}$$

where q is the quality of steam, that is, the percentage of steam in one pound of the mixture of steam and moisture.

If, therefore, in the foregoing problem, the steam contained 2 per cent of moisture, or the quality of steam was 98, the pounds of steam required would have been

$$P_s=\frac{1,000 \times 0.97\ (178-70)}{([897.2 \times 98]+187.5)0.95}=103.4 \text{ pounds.}$$

When the steam is discharged directly into the milk the water of condensation is, of course, added to the milk with the result that the milk contains a greater amount of water than it did originally. In the foregoing problem the weight of water added to the milk was 103.4 pounds, hence the per cent of water added was $(103.4 \div 1,000) \times 100=10.3$.

When exhaust steam is used instead of live steam, the quantity of water added is a great deal more for the reason that the exhaust steam contains a greater amount of moisture. Assuming that the exhaust steam contains 15 per cent moisture and it is discharged into the milk at atmospheric pressure, then the mean temperature difference between the milk and steam is 78.8 degrees and substituting in the formula we have

$$P_s=\frac{1,000 \times 0.97\ (178-70)}{(970.4 \times .85)+78.8 \times .95}=122 \text{ pounds,}$$

and the per cent of water added is $(122 \div 1,000) \times 100=12.2$ per cent.

Standardization of the Power Take-Off for Farm Tractors[1]

By W. Leland Zink[2]

THERE are now three important ways for utilizing tractor engine power. Two of these, the belt pulley and the drawbar, have been in use for years. The third means of applying power, called the "power take-off," has just come into practical use. The power take-off might be defined as a tractor attachment or provision for applying tractor engine power direct to the operating mechanism of some tool or machine while traveling. Let us be careful to distinguish between the various ways of applying tractor engine power. Often the belt pulley and power take-off are confused. Sometimes the power take-off principle is applied from the front or sides of the tractor. The most common application, however, is from the rear end of the tractor. Both tractor-mounted and drawn tools are commonly driven by this type of power application. Particular attention will be given in this paper to the rear-end power take-off as applied to drawn agricultural tools.

There should be no question regarding the mechanical advantage of the power take-off method of applying power over the application of all the power through the drawbar to a tool. An analysis on this point shows that tractor engine power can be applied to a drawn tool through the power take-off with an efficiency of 80 per cent or more. A 50 per cent efficiency, however, is a high figure for applying power to the operating parts of a drawn tool when working through the tractor transmission and lugs back through the drawbar and drawn tool drivewheels and transmission. Several of our present day agricultural tools, for example, the corn picker, have succeeded only due to development of the power take-off. The rice areas bring in another striking example on this matter of efficiency. Before the power take-off came into use a six-foot rice binder was a good load for a 10-20 tractor. Now, however, with the power take-off in service an eight-foot binder can be handled successfully with the same 10-20-hp. tractor. A paper presented before this group one year ago, entitled "The Direct Application of Mechanical Power to Soil Tillage,"[3] also discussed the efficiency advantages of the power take-off. Although the power take-off idea has been in practical use only about five years, we already find power being applied in this manner to over twenty different types of drawn tools such as grain binders, corn pickers, corn snappers, ensilage harvesters, combine harvesters, potato diggers, soil pulverizers, cultivators, cotton pickers, planters, sprayers, dusters, burners, stubble beaters, etc. We also find the power take-off attachment being supplied for over forty different current and obsolete tractor models, or, in other words, practically every tractor built for agricultural use. In almost every case this attachment is now being built and sold by the tractor manufacturers. This rapid growth and application of the power take-off clearly indicates this idea is sound, also that it is here to stay. In fact there is no doubt but that in many cases at least the power take-off will be made regular tractor equipment just as the belt pulley is today. Practically every tractor being sold now in certain areas is fitted with the power take-off attachment at the factory. Already one or two tractor companies build the power take-off as integral part of the tractor. Following up this practice would mean a material saving to the user together with an even more rapid spread of power take-off use.

Naturally this rapid growth of the power take-off has made it extremely difficult to fully standardize this equipment. Some companies are not even standardized within themselves. These facts, along with the added complications caused by the dual use of power, often make the hook-up between the various tractors and drawn power take-off-type tools a difficult problem. The result is that very often it is necessary to make expensive field alterations in order to get a workable hook-up. Even then the connection is often unsatisfactory. Many manufacturers of drawn tools supply special fittings for tractor models of their own line. Others make an effort to supply fittings for several tractors. A few at least try to supply fittings or information for hooking onto any tractor supplied with a power take-off. Likewise several tractor companies supply special fittings or information for hooking onto various take-off-type drawn tools.

Various tractor and implement publications have done a lot toward bringing the existing conditions before the public. This information has greatly helped the trade in meeting the various problems. The "Tractor Power Take-Off Specifications" published in the August 15, 1929, issue of "Farm Implement News" and revised to November 13, 1929 (Fig. 1) is the most outstanding piece of work along this line.

The real solution for all this chaos, however, is to fully

[1]Paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, Chicago, December 1929.

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[3]"The Direct Application of Mechanical Power to Soil Tillage," by J. Brownlee Davidson and Edgar V. Collins. AGRICULTURAL ENGINEERING, Vol. 10, No. 5 (May, 1929).

SPECIFICATIONS OF POWER TAKE-OFFS OF TRACTORS*

(Only rear "agricultural" take-offs included. Clockwise rotation viewed from rear of tractor.)

Tractor Model	Take-off Governed Speed	Size and type of spline connection	Height of connection above ground	Distance Right or Left of Center Line	Distance Ahead or Behind Hitch
Advance-Rumely W	536	1⅛ 6B	19"	11" L.	24" to 15" ahead *
" " X	548	1⅛ 6B	20"	12½" L.	24" to 15" ahead *
" " DoAll	538	1⅛ 6B	22½"	4½" L.	18⅜" ahead
Allis-Chalmers United	530	1⅛ 6B	17¾"	5¼" R.	5¼" behind
Allis-Chalmers 20-35	542	1⅛ or 1¾ 6B	24½"	1¾" R.	1⅜" behind
Case C	535	1⅛ 6B	27¼"	Center	13½" ahead
Case, OC	535	1⅛ 6B	20¼"	Center	12" ahead
Case L	550	1⅛ 6B	32½"	Cent r	18¼" ahe d †
"Caterpillar" Ten	538	1⅛ 6B	15½"	Center	9" ahead
" Fifty 60	536	1⅛ 6B	21¼"	Center	10½" ahead
" Twenty	534	1⅛ 6B	23¼"	Center	8¼" ahead
" Thirty	535	1⅛ 6B	24¼"	Center	8½" ahead
Cletrac "20"	667	1½LH thread	25"	Center	2⅞" ahead
" "30"	745	1½LH thread	23¼"	Center	6½" behind
" "40"	851	1½LH thread	26"	Center	13½" behind
John Deere GP	519	1⅛ 6B	23½"	9½" L.	42¾" ahead
" " D	513	1⅛ 6B	23½"	12½" L.	6⅞" ahead
Huber 20-35 Light Four	536	1⅛ 6B	26½"	12" L.	14" ahead
" Super Four 32-50	515	1⅛ 6B	29½"	11½" L.	14" ahead
" " " 32-45	540	1⅛ 6B‡	20⅜"	11½" L.	14" ahead
" " " 40-65	540	1⅛ 6B‡	20⅜"	11½" L.	14" ahead
McCormick-Deering "Farmall"	536	1⅛ 6B	20½"	Center	32½" ahead
" " 10-20	543	1½LH thread§	28⅞"	1" L.	11¼" ahead
" " 15-30	536	1½LH thread§	34⅛"	¾" L.	111" ahead
Keck-Gonnerman 12-25	540	1⅛ 6B	20"	10½" L.	Even
" " 25-50	540	1⅛ 6B	20⅛	11½" L.	Even
" " 30-60	540	1⅛ 6B	20½	11½" L.	Even
John Lauson 20-35	550	1⅛ 6B	22"	2½" L.	Even
Massey-Harris Wallis 12-20	550	1⅛ or 1⅜ 6B	29½"	1½" L.	111" ahead
" " " 20-30	548	1⅛ or 1⅜ 6B	30½"	⅜" L.	111" ahead
Minn.-Moline Twin City 17-28	536	1⅜ 6B	29"	12" L.	24⅜" ahead‡
" " " 21-32	536	1⅜ 6B	29"	12" L.	24⅜" ahead‡
Oliver Hart-Parr 13-24	548	1⅜ 6B or 1¼ 8C	21¼"	4⅝" L.	1½" ahead‡
" " " 18-36	536	1⅜ 6B or 1¼ 8C	33"	5⅝" L.	10" ahead
Rock Island GR	550	1⅜ 6B	28"	9" L.	11" ahead
" " F	600	1⅜ 6B	29"	9" L.	11" ahead

* Distance adjustable by 3" intervals by shortening hitch. † 27½" ahead on first 3500 Model L tractors.
‡ Early models equipped with 1⅛" 6B.
§ Extension "front power shaft," with knuckle, bearing and bracket, available with 1⅛ 6B spline end. Attaches in front to 1½ LH thread connection of tractor power take-off shaft. [Listed with power binder and corn picker tractor hitches, not in tractor catalog. Made at McCormick Works.]
‖ Varied slightly by arc of swinging drawbar. ¶ 9½" ahead with special drawbar.

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Fig. 1. Specifications of tractor power take-offs now on the market

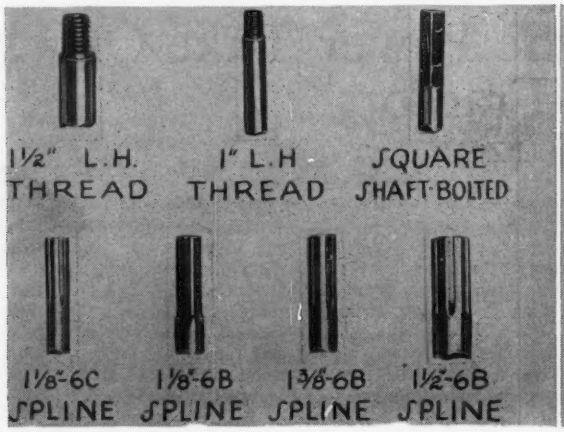
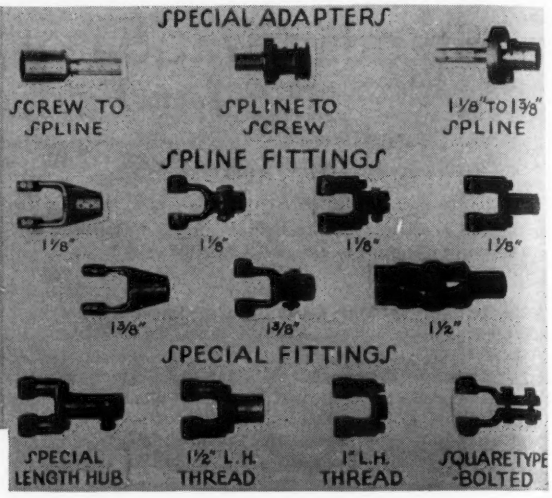


Fig. 2. (Above) Present types of power take-off shaft ends. Fig. 3. (Right) Special adapters required to couple the power take-off members of various implements and tractors, due to lack of standardization



standardize the power take-off. By this I do not mean that we should try to set about devising a set of standards that will meet all existing difficulties. We should, however, draw up a complete plan toward which to work. There is no question but that such a thing can be worked out and handled without serious hardship to anyone, providing all interests can get together and decide for the good of the cause.

Let us keep in mind that a lot of good work on this matter of power take-off standardization has already been done. Considering the newness of this proposition and the tremendous growth of its use, we must agree that the previous standardization work has been of great benefit. As previously mentioned, however, much misunderstanding and trouble remains, for three outstanding reasons: (1) The standards have not been carried far enough, (2) the manufacturers have often disregarded the standards either because of complications in design or indifference, and (3) the existing standards and recommended practice have not been brought before the tractor and implement world in a definite way.

Type and Size of Power Take-Off Shaft Ending. The greater part of our trouble today on this matter of uniform power take-off type and size of shaft ending has been caused either by disregard or ignorance of our present A.S.A.E. standards. On reviewing the present A.S.A.E. standards it will be found that an S.A.E.—6B spline with a 3-inch straight length at the root of the spline is specified. The standards further state that two sizes of spline shall be used—the 1⅛-inch for tractors developing up to 20 b. hp., and the 1⅜-inch for tractors developing up to 40 b. hp. If we will note Fig. 1 and Fig. 2 we will find many variations from these standards. The specifications show that five tractors are still using the 1½-inch left-hand thread, three are using a 1½-inch—6B spline, two are using a 1⅛-inch—6C spline, four tractors developing over 20 b. hp. cannot be supplied with a spline size larger than 1⅛-inch. In addition to the peculiarities noted in the specifications, several power take-off shafts are being found with a root length of less than 3 inches. Also one tractor requiring an extension shaft for drawn tool work is being supplied with a square shaft ending. In another case the extension shaft is supplied with a 1-inch left-hand thread. There are also several power take-off-type tools which cannot be supplied with a 1⅜-inch spline fitting. At least one machine is not supplied with either a 1⅛-inch or 1⅜-inch spline fitting.

It can be readily seen that with this tremendous variation of types and sizes of power take-off shaft endings many hook-up difficulties are constantly coming up. Furthermore, these troubles are not of a type that can be readily corrected at the local implement store or blacksmith shop. Generally they mean a long delay for parts, a lot of telephone and telegraph service, or an expensive expert machinist proposition.

It seems only reasonable that we should come to a more definite agreement regarding the type and size of take-off shaft ending. I would like to offer two suggestions. One with reference to the standards is that we strike out the 1⅛-inch spline size, thus bringing our specifications to one size only. The other suggestion is that we make every effort possible to conform with the adopted size and type of take-off shaft ending. Following this program would mean a material saving to the trade by the elimination of shaft sizes, fittings, and special adapters now being supplied. (See Fig. 3).

Retaining Means. There are several methods in use for retaining universal fittings to the spline shaft. (See Fig. 4.) The drilled hole through the root of the spline, the drilled and tapped shaft end, the threaded shaft ending and the screw and bolted endings are being used. In addition there is some variation regarding location of the drilled hole through the root of the spline. The A.S.A.E. Power-Take Off Standards briefly state that the retaining means shall not extend more than 1-inch from the end of the shaft. This appears to be a vague statement. No doubt this point should be more fully covered. Personally, I prefer the 3/16-inch cotter pin hole cross-drilled through the root of the spline at a point 1 inch from the end of shaft as discussed and temporarily adopted three years ago. If there should still be some disagreement on this point I would suggest that both the cotter hole and a ½-inch, thirteen-thread tapped ending such as discussed at previous standards meetings be provided.

Power Take-Off Speed and Direction of Rotation. With reference to direction of rotation very little need be said. All manufacturers seem to be in agreement on this matter. The proper power take-off speed and direction of rotation have been clearly covered under the A.S.A.E. Standards. The speed of 536 r.p.m., plus or minus 20, seems to work out satisfactorily on all installations known; also the range does not seem unreasonable to meet. Most of the tractor companies are meeting these specifications in fine shape. However, the specifications (Fig. 1.) show one model to be below and four to be above the range specified. One is as much as 53 per cent above maximum speed permitted. It might be well at this time to check up on the power take-off speeds for foreign shipment. It is reported that the German power take-off standards call for a speed of over 600 r.p.m. If this is true, possibly they

could still be brought into agreement with our standards.

Power Take-Off Shaft Location. The power take-off shaft must be quite definitely located: (1) With respect to height, (2) with respect to the tractor center line and (3) with respect to proper distance ahead of the point of hitch.

In regard to the power take-off location with respect to height, the A.S.A.E. Recommended Practice states that the shaft shall be located 25 inches, plus or, minus 5, above the ground. A review of the specifications (Fig. 1.) shows that ten tractors do not come within the height range specified. I have but one suggestion to offer on our present recommended practice: Possibly it might be best to hold the height allowance with respect to the normal drawbar height and not the ground line. I am suggesting this in view of the fact that it is extremely important to hold the drawbar and power take-off within certain limits of each other because of the telescoping effect on the drive members when going over rough ground. This point of considering the power take-off height location with respect to the tractor drawbar is becoming more evident with the general tendency toward lower drawbars. Several of our new tractor designs are now coming through with a drawbar height of around 10 inches in place of 15 inches as formerly specified. Several tractor compaines are making the mistake of raising the power take-off shaft too high I know of one model just out which has a power take-off height of over 40 inches. This again is a case where the power take-off standards are being ignored either through indifference or ignorance. This tractor has the possibility of an almost ideal power take-off installation, not only with respect to location, but also with regard to protection to the operator.

In regard to the power take-off location relative to the tractor center line the A.S.A.E. Recommended Practice specifies a location of within 10 inches on either side of the tractor center line. A survey of the power take-off specifications (Fig. 1.) shows that twelve of the thirty-six tractors listed do not come within the stated range. This whole matter of location with respect to the tractor center line is a vital one to the success of the power take-off. I frankly feel that even the range of 10 inches on either side the tractor center line is too much. It can be readily appreciated that it is necessary to keep the point of hitch fixed directly below the power shaft drive members to prevent serious telescoping while turning. On hook-up with tools having a heavy drawbar pull, however, it is often almost impossible to hook as much as 10 inches off the tractor center line without serious steering difficulty. Likewise it is often impossible to hook certain tools such as cultivators, planters, etc., more than a few inches if any, off the tractor center line. There is no question but that, all installations considered, the power take-off should be located just as near as possible to the tractor center line. A careful observation of all different types of installations now in the field would indicate that a 5-inch range either side of the tractor center line should be the maximum allowed.

The power take-off location relative to the point of hitch is the third location item of importance. This point, by the way, is perhaps our most serious matter on the power take-off situation. Up until very recently practically no information has been available to the trade regarding various tractor power take-off and drawbar relative positions fore and aft. The "Farm Implement News" power take-off specification sheet (Fig. 1.) is a real piece of service on this point. The last column lists the various locations encountered. The A.S.A.E. recommended practice states that the power take-off or an extension of same shall extend far enough to the rear to clear the tractor fenders and platform. They clearly state that this extension if required shall be furnished by the tractor company. The recommended practice further states that the point of hitch shall extend 10 to 15 inches back from the power shaft ending. These recommendations appear to be reasonable. A review of the last column of the power take-off specifications (Fig. 1.) indicates that 61 per cent of our present installations do not come within the recommended fore and aft range. In fact it will be noted that in several cases the drawbar actually sets ahead of the power shaft. The difficulty encountered on such installations is illustrated in Fig. 5. It will be noted in this case that the front universal joint must take even more angle than the hitch itself. This is almost an impossible situation for the universal joint builders to meet. In the other case the turning angle is divided between two universal joints.

On this matter of using a power take-off extension shaft for clearing the tractor fenders and platform, a lot might be said. Power take-off shaft extension assemblies are required on certain tractors (Fig. 6). At the present time, however, in many cases these parts are being grouped with drawn tools for use in adapting them to a certain tractor which does not have a proper take-off location. It would seem only logical to expect that such a bundle or group of fittings should be supplied as a regular part of the power take-off attachment. Likewise oftentimes special extension hitch assemblies will be found grouped

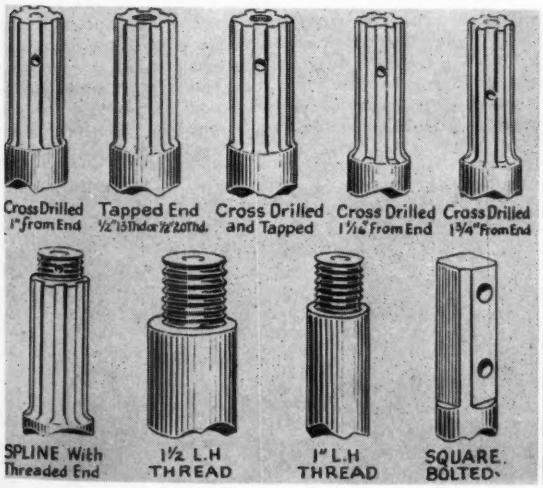

Cross Drilled 1" from End
Tapped End ½"-13 Thd or ⅞"-20 Thd.
Cross Drilled and Tapped
Cross Drilled 1 1/16" From End
Cross Drilled 1¾" From End
SPLINE With Threaded End
1½ L.H THREAD
1" L.H THREAD
SQUARE BOLTED

Fig. 4. (Left) Various types of retaining means.

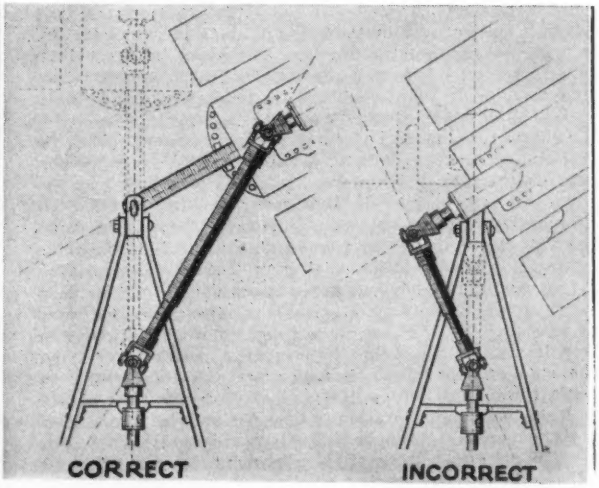
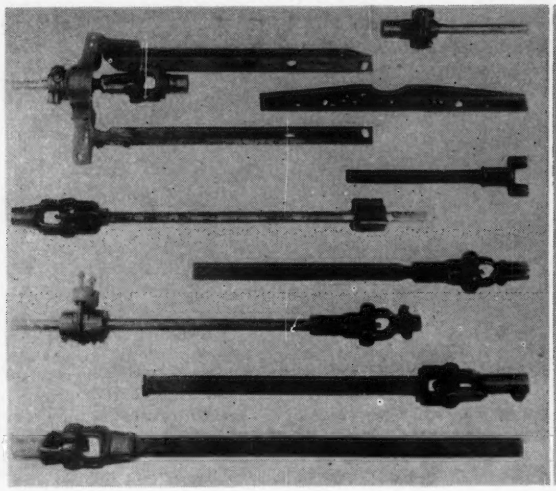


Fig. 5. (Right) Illustration of correct and incorrect relative positions of the hitch point with reference to the power take-off universal joints



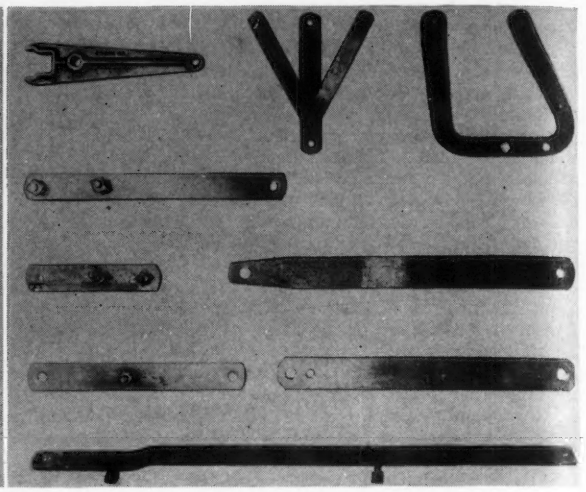


Fig. 6. (Left) Special power take-off extensions. Fig. 7. (Right) Special hitch extensions

with certain drawn tools. No doubt this part should also be standardized so as to be adaptable to the standard power take-off and then grouped with the power take-off attachment. At least one tractor is doing this today, not only in reference to the drawbar extension but in regard to the power shaft extension also. This seems to be a very sensible arrangement. Special drawbar extensions now being required in hooking up certain tractors and drawn tools are shown in Fig. 7. It seems that in the case of the grain binder a high drawbar extension has been used. This arrangement was no doubt made to permit rice binder tongue clearance on working over high irrigation levees. No doubt, however, this necessary tongue clearance could have been handled by using an arched binder tongue, thus permitting the use of a standard drawbar extension, where such is required. If the power take-off shaft and drawbar extensions should be an excessive burden on the power take-off attachment, because of their not being required on certain tools, especially on mounted type machines, possibly it might be well to pack them in a special bundle and stock them at every warehouse carrying the power take-off attachment. It would also be well to emphasize at this time the importance of using a standard spline shaft ending on the power take-off shaft extension. At least one of our present shaft extension assemblies (Fig. 6) uses a square type of shaft ending, and another uses a 1-inch left-hand thread. It is important that the drawbar extensions be fixed rigidly and be extended back directly below the power shaft line to a point that conforms with the recommended 10 to 16-inch distance back of the shaft ending.

This whole matter of correct power take-off shaft location has been a difficult problem. This is especially true on tractors which were already in production at the time the power take-off idea was introduced. Even on new designs it is often found almost impossible to come through the rear of the tractor at the ideal location because of either the differential or rear axle.

No doubt, however, this whole problem could be very much simplified without a serious addition in cost or loss of efficiency by the use of a short roller chain. In this way it would be possible to bring the power back along the side of the tractor if necessary and then swing in again toward the center line, and at the same time obtain a desirable height location. The designer of the drawn tools, especially those having three universal joints, can greatly help the drive shaft alignment by providing an adjustable bearing bracket just back of the second universal joint. (Fig. 8 shows an example of such a bracket.) It should be adjustable both vertically and crosswise and be provided with a self-aligning bearing feature. Such an arrangement can usually be mounted on the drawn-tool hitch. Another helpful feature is the provision for some adjustment in the tractor drawbar length. It will be noted that two of the tractor models listed in the specifications are provided with this feature. (Also see Fig. 9.) Such an arrangement readily permits obtaining a drawbar length that will give the most satisfactory telescoping drive shaft service. It is important, especially where short telescoping members are used, that the hitch be correct, otherwise the members will either pull apart or strike together on sharp turns over rough ground.

Safety Features. That old slogan, "Safety First," cannot be emphasized here too strongly. Past discussions have taken up the matter of possible drastic legislation against the power take-off if proper guards and protection to the operator were not provided. No definite standards, however, have been provided on this matter. The A.S.A.E. Recommended Practice mentions that adequate guards for the protection of the operator shall be furnished. The division of obligation, however, between the tractor manufacturer and drawn tool builder is not clear.

No doubt it is only proper that the builder of the drawn tool should provide the necessary guards for protecting the operator from the power drive shaft and universal joints back of the one which attaches to the tractor power take-off shaft. The matter of providing a proper guard for the front universal joint, however, is a different proposition. It is almost impossible for the drawn tool builder to provide a satisfactory front universal joint guard which will fit all tractors. (Fig. 10.) It,

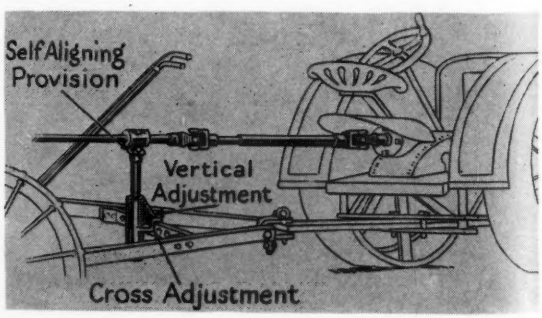
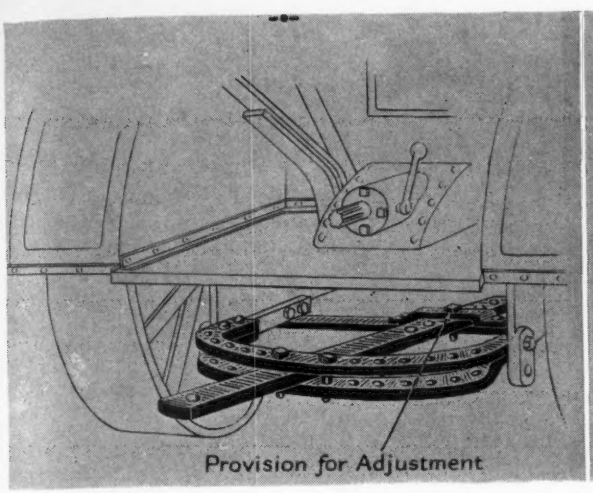


Fig. 8. A simple type of adjustable front bearing



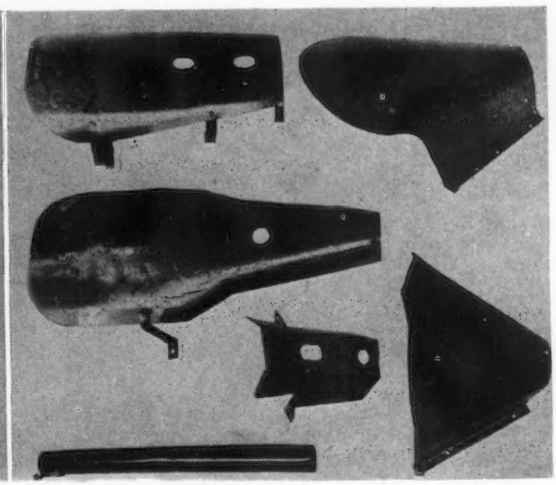


Fig. 9. (Left) An adjustable length drawbar ideal for power take-off use. Fig. 10. (Right) Various types of shields to protect the operator from injury from the power take-off

therefore, seems logical that the tractor manufacturer should furnish a satisfactory guard for the front universal joint and be obligated to supply it as regular equipment with the power take-off attachment. Possibly some specifications as to the universal joint diameter and turning angle to be provided for should be decided upon. It is extremely important that such a guard not only protect the operator's clothing from getting into the universal joint from above but from the sides and bottom as well. I know of at least one serious accident caused by not having proper protection of this kind. It is also desirable that this guard be made of heavy material and so constructed that the first drive member back of the front universal joint, usually a telescoping member, cannot drop down on an accidental pulling apart and lock against the drawbar or swing up and strike the seat. This danger is sometimes encountered on short turns over rough ground, in cases of the hitch breaking loose or in case of accidental engaging of the power take-off clutch when traveling with the tractor with only the first universal joint and part of the telescoping member attached to the tractor, as when going to or from the field.

It is impossible to overemphasize the importance of this front universal joint guard. Most of our fatal accidents in connection with the power take-off—there are several each season—have occurred by the operator getting caught at the front joint either because there was no front joint guard at all or because there was not an adequate one.

Another important matter on the item of safety features is the use of a power take-off clutch. No mention is made of this in the standards. It is also very important that the clutch control be as proof as possible against accidental engagement while the operator is getting on and off the tractor. Several serious accidents have happened in this way. It is also important that this clutch be accessible to the operator and easy to throw out quickly On extremely short turning tractors it would be desirable to use a friction type clutch which might be thrown either in or out at will while making turns, thus protecting the universal joints from extreme wear.

It is important that all encouragement possible be given to the elimination of projecting parts such as set screws, bolts and pins, Also the designers of the drawn tools should be encouraged to help matters where possible by locating the hitch and frame parts around the power drive members so as to protect the operator from getting against the moving driveshaft members. Tractor designers should take advantage of every possible opportunity for protecting the operator from the power take-off and the universal drive members. Often by keeping the tractor seat slightly forward or by raising the tractor platform or lowering the power take-off position a much greater operator protection can be worked out. Possibly these last points cannot be made a part of the power take-off standards but might well be considered as suggestions for recommended practice.

SUMMARY

I have discussed:

1. The size and type of power take-off shaft ending
2. Method of retaining the front fitting to the spline shaft
3. The power take-off speed and rotation
4. The power take-off shaft location with respect to height, center line, and position relative to point of hitch
5. The various safety features.

I feel confident that only practical suggestions for the complete standardization and refinement of the power take-off have been offered; also that the carrying out of this program would make it possible to quickly hook any tool designed for take-off use onto any tractor which can be supplied with a power take-off. I well realize that there have been differences of opinion on many of the points. The thing to do, however, is not to battle among ourselves on this situation but to get together in every way possible. Let's give and take where necessary. The automotive engineers have fought these situations successfully on many automobile items; the electric interests have formulated and complied with uniform specifications; railroads have standardized on couplings, hose fittings etc.—these are just a few of the outstanding examples of the possibilities of standardization. All this effort has meant cheaper production, lower overhead, easier selling and greatly improved satisfaction with the product.

The Power and Machinery Division of the American Society of Agricultural Engineers can contribute materially to the general progress of the tractor and implement industry by its whole-hearted promotion and support of every means which will bring about complete and satisfactory power take-off standardization. We have letters indicating that the Division of Simplified Practice of the U. S. Department of Commerce stands ready to aid as a neutral body in forwarding this work and bringing the adopted standards to national and international attention. Almost every tractor, implement and technical organization stands ready to cooperate. Without a doubt this matter of further power take-off standardization is worthy of attention and the time is ripe for immediate action.

Agricultural Engineering Digest

A review of current literature on agricultural engineering by R. W. Trullinger, specialist in agricultural engineering, Office of Experiment Stations, U. S. Department of Agriculture. Requests for copies of publications abstracted should be addressed direct to the publisher.

Water Supply from Rainfall on Valley Floors, A. L. Sonderegger (American Society of Civil Engineers (New York) Proceedings, 55 (1929), No. 5, pt. 1, pp. 1139-1165, figs. 13).—This paper presents an analysis of the phenomenon of rainfall penetration on valley floors in semiarid areas and a discussion of methods for the quantitative determination of the resulting water supply, with special reference to conditions in southern California. Special attention is devoted to the determination of rainfal penetration from soil moisture tests and from springs in the Murrietta-Temecula area, determination of penetration on valley floors by comparison with mountain run-off in San Bernardino Valley, and the determination of penetration from rainfall and irrigation rise of water in test wells in Pauba Valley.

The results show that for an alluvial valley fill of crystalline origin, the distribution and rate of penetration of moisture from rainfall over large areas are essentially nonuniform and percolation will concentrate in numerous well-defined ducts. Deep penetration may occur during years of deficient rainfall when the maximum consumptive use of the cover is not satisfied; particularly is this true when the formation is modern.

For like seasonal rainfall the intensity of the maximum storm of a season is greater in the valley than in the mountain watershed and so is also the resulting water supply. For like intensity of the maximum seasonal storm the water supply produced in the valley is approximately the same as that in the mountains, conditions of cover and soil being similar. Given the relation of maximum seasonal storms of mountains and valley, deductions may be made from the known run-off of a mountain area to the available water supply of the adjacent valley floor.

There appears to be a more or less fixed relation between the seasonal rainfall of a watershed and the consumptive use of its cover, which remains approximately the same for kindred watersheds of a region. Inasmuch as the consumptive use is only the complement to the run-off, the rainfall run-off relation of a mountain watershed will permit of definite conclusions as to the water supply from local rainfall of its adjacent recipient valley area if these relations are reduced to a common basis and expressed in percentage of the mean rainfall Storm run-off of the valley floor is a minor factor, except for compact formations under the effect of the maximum storm of a wet year. A substantial percentage of the rainfall on the valley floor becomes available, varying with the amount of precipitation, the wetness of the preceding season, and the character of soil and cover.

The Solar Heater, A. W. Farrall (California Station (Berkeley) Bulletin 469 (1929), pp. 32, figs. 21).—The results of studies of the solar heating of water are reported and the design of simple solar heaters for this purpose is described. The solar heater seems to offer a practical means of supplying hot water for dairy and household purposes. It should be used in conjunction with a well insulated water-storage tank, and for continuous service it should have an auxiliary oil, gas, or electric heater. For average conditions in the warm interior valleys of California, 1 square foot of glass-absorber area should be used per gallon of water to be heated per day. The most efficient location for the absorber is on the south slope of an unshaded roof.

The tests show that temperatures of 280 degrees (Fahrenheit) are obtainable under the glass of a well-insulated solar heater. Daily averages of as high as 3 B.t.u. per square foot per minute between the hours 8 a.m. and 5 p.m. are easily obtainable by simple solar heaters. The absorber box should be insulated against heat loss. Good cork insulation is recommended. If high temperatures are desired, it is best to use a double glass cover with air space between. A tight glass should be placed over the absorber box in order to retain the heat and to prevent air currents from cooling off the pipes.

The area of the pipe or absorbing surface in direct contact with the sun's rays should approach the area of the glass as nearly as possible, for maximum absorption. Embedding coils in concrete or other materials having good conduction greatly increases the efficiency of the absorber. This type works fairly satisfactorily in protected places, without the use of a cover glass. The inside of the absorber and the exposed part of the water coils should be painted a dull black.

The absorber should be set at an angle such that it will be most efficient in the early spring months, rather than in the summer; a 35-degree angle to the horizontal is suggested for places with the latitude of Davis, Calif. The maximum heat absorption takes place when the plane of the absorber is kept at 90 degrees to the sun's rays; the most satisfactory practical installation, however, is to build the absorber stationary and of a size sufficient to furnish the required amount of heat under all conditions. Some heat is absorbed by the solar heater even on hazy and cloudy days. Solar heating systems should have a large storage or reserve capacity.

The percentage of solar radiation reaching the earth is largely affected by atmospheric conditions, and also varies from day to day at the source.

A shut-off valve in the discharge line between the absorber and the tank may be advantageous in some installations, where it is desired to stop the back circulation due to cooling of the absorber at night.

A Farm Machinery Survey of Selected Districts in Pennsylvania, H. B. Josephson, W. R. Humphries and L M. Church (Pennsylvania Station (State College) Bulletin 237 (1929), pp. 15, figs. 3).—A summary of data on the use of machinery on Pennsylvania farms is presented, which was prepared by the station in cooperation with the U.S.D.A. Bureau of Public Roads and the Pennsylvania Department of Agriculture.

Among other things it was found that tractors were used 36.6 days per year, 23.9 days for drawbar work, and 12.7 days for belt work. Walking plows were in common use in all sections studied; riding plows were rarely found, with the exception of two-way sulky plows. The one-row riding cultivator, used with two horses, was practically universal throughout the State.

The team of two horses was the most common power unit. Some farmers used four horses for harrowing, loading hay and cutting grain. In Lancaster County three horses were commonly used for plowing, harrowing and cutting grain.

The years of service rendered by machines did not vary greatly with the amount of use. The cost per year for using machines is a better index than cost per acre, because of the great difference in the amount of annual use. The cost of using machines, when figured on a per acre basis, is high in many cases because of small acreage.

Book Review

The "Farm Implement News Buyer's Guide" for 1930 is now available. It is printed in the usual form, the listing of manufacturers, lines, branch houses and jobbers having been revised and brought up to date. The Farm Implement News Company, 431 S. Dearborn St., Chicago, Illinois, is the publisher.

"Lumber" — simplified practice recommendation R 16 - 29 of the U S. Bureau of Standards has been reprinted in the fourth edition and is available from the Superintendent of Documents, Washington, D. C., at thirty cents per copy.

"Principles of Farm Mechanics" by M. A. Sharp and W. M. Sharp is a new addition to the Wiley agricultural series edited by J. Brownlee Davidson. As a text for farm mechanics courses for high school students, agricultural college freshmen and those who plan to teach vocational agriculture, it attempts to make it easy for the teacher to do a good job of teaching, and for the pupil to learn the principles involved in ordinary farm mechanics work. Each chapter is introduced with a number of thought-provoking questions relating to the subject matter and popular phases of its application, with a view to interesting the pupil. Lesson plans included are justified on several premises, including beliefs that most shop teachers do not have the time, experience or training to prepare good lesson plans, and that the boy is more important than the teacher and any device which will improve the service to the boy should be used. Chapters cover why study farm mechanics? rope, soldering, glazing, drawing, care and use of woodworking tools, elementary carpentry, harness repair, pipe fitting, elementary blacksmithing, cold metal tools and their uses, repairing farm machinery, belts, pulleys and babbitt bearings, repairing gasoline engines, farm buildings, concrete, and the school shop and its equipment. John Wiley & Sons of New York and London are the publishers and list the book at $3.00.

Who's Who in Agricultural Engineering

W. G. Ward

Frank Adams

H. B. White

W. L. Zink

W. G. Ward

Walter Gilling Ward (Mem. A.S.A.E.), extension architect at Kansas State Agricultural College, is on sabbatic leave from that institution while working for a master's degree in agricultural engineering at Iowa State College. He already holds a bachelor's degree in architecture received from Kansas State Agricultural College in 1912 and the professional degree of "architect" granted by the same school in 1922. From 1912 to 1914 he was instructor in drawing at Michigan State College, and from 1914 to 1920 in charge of the architectural division at North Dakota Agricultural College. Since 1920 he has held his present position as extension architect at Kansas State Agricultural College, and since 1925 has been in charge of all agricultural engineering extension work at that school. As a member of the Society since 1921 his chief interest has been in the Structures Division. At present he is a member of the Subcommittee on the Design of Animal Shelters and of the Committee on Agricultural Engineering Extension. At the Chicago meeting of the Structures Division in December he reported on the findings of the Division's dairy barn questionnaire project.

Frank Adams

Frank Adams (Mem. A.S.A.E.) is collaborator in the division of agricultural engineering, U. S. Department of Agriculture, and professor and head of the division or irrigation investigations and practice, University of California. In addition he holds several advisory positions as irrigation economist and as consulting engineer. Studies in economics and sociology obtained for him a bachelor of arts degree from Leland Stanford University in 1901 and a master of arts degree from the University of Nebraska in 1906. His technical knowledge of irrigation and engineering was obtained through independent study. Since the beginning of the present century he has been almost continuously in the service of the U. S. Department of Agriculture, holding successively positions as agent and expert (in irrigation), irrigation assistant, irrigation engineer, irrigation manager and collaborator. In spite of his strenuous activities as a scholar, engineer, author and teacher he has found time for the work of the Society, including the chairmanship of the Pacific Coast Section in 1925-26 and service on the Committees on Irrigation and Land Settlement at various times. He recently succeeded the late George C. Kreutzer as chairman of the latter committee.

H. B. White

Hall B. White (Mem. A.S.A.E.) is in charge of the farm building work of the division of agricultural engineering, University of Minnesota. After working at the construction of farm buildings for a while as a young man, he went through the college of agriculture at the University of Minnesota, majoring in agricultural engineering, and upon graduation in 1908 was given an instructorship in the division of agricultural engineering at that institution. During 1918 he had charge of the engineering training of more than one thousand soldier-mechanics. Following this he got back to farm structures work in his present position in charge of the then newly-organized section of farm buildings. Under his direction the section has conducted research in grain bin ventilation, dairy barn efficiency, dairy barn ventilation and farm building costs, and has prepared farm building plans of recognized merit. In 1928 the University of Wisconsin granted him a master's degree for research work on dairy barn efficiency which he conducted at that school. Since becoming a member of the Society in 1919 he has been active in the work of the Structures Division and has served as secretary of the North Central Section.

W. L. Zink

W. Leland Zink (Mem. A.S.A.E.) is chief engineer for the General Implement Company. After growing up on a large grain and livestock farm in central Iowa, he had started his college education in agricultural engineering when war conditions encouraged him to enlist. After the war he returned to Iowa State College and in 1922 received his bachelor's degree in agricultural engineering. With sheepskin in hand he went to the division of agricultural engineering, University of California, as instructor. After two years of teaching and research in this capacity he went to Southern Mexico to do general engineering work for a chain of large coffee plantations and after a few months was employed by the International Railroad of Central America in general engineering work in connection with a survey for a new road. Leaving this position in the summer of 1926 to get back to the United States he became associated with the General Implement Company as designer and field engineer, and was soon moved up to the chief engineer's desk. In this connection he has played a large part in the research, design and testing upon which the "Pulverator"—plow-harrow product of the company—is based.

AGRICULTURAL ENGINEERING

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Contributions of interest and value, especially on new developments in the field of agricultural engineering, are invited for publication in this journal. Its columns are open for discussions on all phases of agricultural engineering. Communications on subjects of timely interest to agricultural engineers, or comments on the contents of this journal or the activities of the Society, are also welcome.

Original articles, papers, discussions, and reports may be reprinted from this publication, provided proper credit is given.

RAYMOND OLNEY, Editor

R. A. Palmer, Assistant Editor

Getting Down to Brass Tacks

NO TIME was spent in philosophizing on the advantages and disadvantages of large-scale farming when J. S. Bird, Hickman Price, and E. G. McKibben presented papers (published in this issue) on the subject at the December meeting of the Power and Machinery Division of the American Society of Agricultural Engineers. Mr. Bird and Mr. Price told what problems they have run up against and how they are solving them in the large-scale production of wheat, and Mr. McKibben gave a mathematical analysis of some of the factors determining the effective capacity of field machines.

Large-scale farming is here to stay; we might as well make the best of it. Topography will no doubt be the principal permanent factor in limiting the extent of large-scale farming. On the level plains it would be profitable to use, and we may ultimately expect to see, much larger and more expensive machine units than are now available. In hilly sections large-scale farming as known on the plains will never be possible, but when the most profitable sizes of farms and of farm machine units for various conditions are determined they will in all cases be larger than those in use at present. The scarcity of competent managers for large-scale farming projects is at present the limiting factor in their development. These are a few current thoughts which indicate the trend.

New Light on Efficiency

UNLESS we miss our guess E. G. McKibben's paper on the fundamental factors determining the effective capacity of field machines, published elsewhere in this issue, will some day rate as a classic among treatises on production engineering in agriculture. It is the first mathematical analysis we have seen of the influence on the efficiency of a field machine of factors outside of the machine itself. It is a big contribution to the slow accumulation of agricultural engineering literature on operation analysis, and to the point of view of agriculture on scientific management.

Notwithstanding the pioneering nature of the work it gives knowledge of great practical value to farmers and to implement manufacturers. To the quarter-section, horse farmer interruptions were frequently a welcome break in the monotony of the day's work. But modern power farming requires too much thought, even on the part of machine operators, to grow monotonous. Mr. McKibben has shown that as the sizes of farms and of field machine units increase, interruptions become unsatisfactory vacations, and more expensive than ordinarily realized. Interruptions proportional to the area worked are completely tabooed, and even such apparently minor items as turning at ends of the field must be cut to a minimum in the effective use of large machines.

There is opportunity for a great deal more of the character and caliber of research being done by Mr. McKibben. Temporarily we have developed the potential efficiency of farm machines far above the efficiency of their management and operation. The latter has, in fact, become a limiting factor in the lowering of farm production costs. It warrants attention.

Timely Revision

FIVE years ago the power take-off was "hot off the griddle" of experimental engineers and was undergoing its first practical test in the hands of a considerable number of farmers. It proved its potential value and manufacturers took steps to provide it for their models.

Much was yet to be learned, however, about what would be the best engineering practice in such details as type and size of shaft endings, retaining means, speed and direction of rotation, location, and provision for the safety of the operator. There was no knowledge of these matters on which standardization might have been based.

Engineers faced first the problem of designing power take-offs to fit tractor and drawn-tool models then in production; models which were designed without thought of tapping the tractor's power through a new appendage. Expediency rather than perfection of design was the rule of the day. In the absence of definite information each engineering department had to follow its best judgment as to engineering practice.

Although costly, this was a necessary phase of power take-off development. It showed some engineers that their pet theories would not work out so well in practice. It showed some manufacturers that their tractors and implements needed redesigning before the power take-off could be adapted to them. It showed everyone concerned the importance of standardization more forcibly than could have been done in a theoretical manner. It showed the limitations of the elementary standards set up by the American Society of Agricultural Engineers in 1927 and revised in 1928.

Now all the good which could come from the chaos of early development has been accomplished. We have entered the period of production of tractors and drawn tools designed with the power take-off as an integral part. It will save the manufacturers a great deal of expense if they can follow standards in the original design of these new models.

W. Leland Zink, chief engineer, General Implement Company, has analyzed and summarized the engineering considerations involved in each point subject to standardization. Probably this work by Mr. Zink (published in this issue) more than any other factor, made possible an agreement on proposed revisions by engineers who attended the standards conference on the subject called by the American Society of Agricultural Engineers in Chicago on December 4 last. When the revised standards drawn up in that conference have the approval of the American Society of Agricultural Engineers Standards Committee, the interested manufacturers, and the A.S.A.E. membership they will warrant and encourage a high degree of adherence, promote farm and manufacturing efficiency, and be a credit to the Society.

A. S. A. E. and Related Activities

Pacific Coast Section Holds Interesting Meeting

ENGINEERING liberals attending a meeting of the Pacific Coast Section of the American Society of Agricultural Engineers, at Davis, California, January 27, heard and discussed favorably various planks in a proposed revolutionary platform on soil tillage. Dr. F. J. Veihmeyer, associate irrigation engineer of the University of California, reported the findings of secret investigations on "Soil Moisture and its Relation to Cultivation and Plant Growth" which have revealed vulnerable points in the conservative platform now in force.

H. B. Walker, professor and head of the division of agricultural engineering, University of California, whetted the enthusiasm of the body for a further investigation of alleged malpractices in cultivation in a paper, entitled "The Engineer's Interest in Tillage Research." A plank on "Rotary Plows" was offered by O. M. Bullock, manager of the Bullock Garden Tool Company. L. J. Fletcher, agricultural engineer, Caterpillar Tractor Company, in discussion urged the expediency of advancing the cause of tillage reform step by step rather than by revolutionary tactics. It was finally decided that the Section should gain strength for the cause by discreetly sowing the seed of discontent at the coming annual meeting of A.S.A.E. at Moline.

An address of welcome by Dr. W. L. Howard, director of the Davis branch of the college of agriculture, University of California; a paper, entitled "Cooperative Possibilities in the Development of Better Farm Structures," by Max E. Cook, agricultural engineer, California Redwood Association; the business meeting; and a dinner after which L. J. Fletcher told some of his experiences in Russia, effectively diversified the program.

Elected to direct the destiny of the Section until the next annual meeting were W. L. Paul, experimental engineer, John Deere Plow Company, San Francisco, chairman; B. D. Moses, associate professor of agricultural engineering, University of California, Hobart Beresford, professor of agricultural engineering, University of Idaho, and M. R. Lewis, irrigation engineer, Oregon State College, to be first, second and third vice-chairmen, respectively; Walter W. Weir, associate drainage engineer, University of California, to continue as secretary-treasurer; and L. J. Fletcher, to serve on the executive committee.

A tentative understanding that a spring meeting should be held at Corvallis, Oregon, if satisfactory arrangements could be made, was agreed upon. The Section voted to extend an official invitation to the Reclamation Division of the Society to hold its next meeting in California with the Section acting as host.

Proposed Roller Chain Standards

ACTIVITIES in roller chain standardization undertaken by the American Engineering Standards Committee in 1924 have resulted in proposed American Standards which are now under the scrutiny of interested organizations pending final approval and adoption. The report of the American Standards Association subcommittee on roller chains has been tentatively approved by the agricultural power equipment division of the S.A.E. Standards Committee.

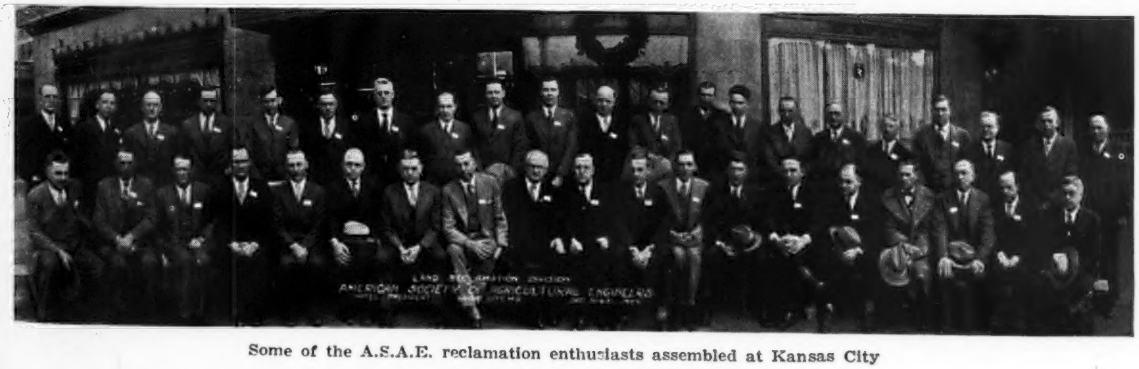
Prominent agricultural engineers in the latter body are O. B. Zimmerman, International Harvester Co., chairman; A. H. Gilbert, Rock Island Plow Company; P. E. Holt, Caterpillar Tractor Company; H. E. McCray, Deere and Company; John Mainland, Advance-Rumely Company; and O. W. Sjogren, Killefer Manufacturing Company. The report which it has tentatively approved covers roller chains of the types commonly used in motor trucks, motorcycles, tractors, industrial machinery and machine tools. Section 2 of the S.A.E. Journal for January 1930 contains the report.

American Engineering Council

SIXTY delegates attended the annual meeting of American Engineering Council in Washington, D. C., on January 10. Officers elected for 1930 are C. E. Grunsky, president; L. B. Stillwell, G. S. Williams, L. P. Alford and O. H. Koch, vice-presidents; and Dr. H. E. Howe, treasurer.

William Boss, past-president of the American Society of Agricultural Engineers, and the Society's representative on Council, was elected to its administrative board. The A.S.A.E. also has an unofficial representative on the Council and its executive committee in the person of Thomas D. Campbell, large-scale wheat farmer and member of A. S.A.E. Mr. Campbell was recently elected one of the representatives of the A.S.M.E. on the Council.

A report of the public affairs committee was presented covering proposed legislation and other questions of national interest and engineering responsibility. The bills and questions, recommendations of the committee and grounds given for the recommendations are briefly: Development of commercial aviation—reiterate endorsement of the Council for this development but oppose Senate Bill 2214 as impracticable; development of national city parks consistent with all major elements of city planning —favor Crampton Bill (H.R. 26) but recommend amend-



Some of the A.S.A.E. reclamation enthusiasts assembled at Kansas City

ment to permit private hydro-electric development at Great Falls, as consistent with flood control, navigation and proper city and park planning; beach and shore erosion—oppose H. R. 5575, of value to local coastal interests rather than the general public; St. Lawrence waterway—amend H. R. 733 to have United States representatives on the international board appointed by the President and including at least one-half civilian engineers, and the remainder, qualified engineers in federal practice; Muscle Shoals—approve Presidents Hoover's recommendations in principal, oppose bills contemplating government ownership or operation or setting aside the Federal Water Power Act; highways—no recommendations on present bills as they deal more with the financial policy of the United States than with engineering; stabilization of wages to aid industry—oppose H. J. Res. 162 as impracticable; commission to study mobilization of resources in time of war—oppose S. J. 20 and H. J. 41 as vague and indefinite; highway to connect Mt. Vernon with Arlington Memorial Bridge—oppose S. J. Res. 91 to amend the act, on the grounds that the Federal government should not nullify the condemnation laws of any state for such purpose; joint congressional committee on unemployment—oppose H. J. Res. 169, because the census and the Department of Labor statistics on the subject will be more satisfactory; reforestation—support the Clark Bill (H. R. 5694) and the McNary Bill (S. 2246) providing for additional appropriations; receipts from national forests paid to states—oppose McNary Bill (S. 2366) to increase the amount because the percentage named is believed exorbitant; use of United States' and adjacent lands in Northern Minnesota—uphold Shipstead-Nolan Bills (S. 2498 and H. R. 6981) with amendments; detail of government engineers to Latin-American republics—oppose Oddie Bill (S. 120) because it disguises provisions to present money to those countries, permits government employees to receive two salaries simultaneously and does not limit time an engineer from the Bureau of Public Roads may serve a foreign country.

American Standards Association

AT THE annual meeting of the American Standards Association in December, William J. Serrill, president, announced that it has become a member body of the International Standards Association. As the result of this action all of the national standardizing bodies except those of Great Britain, Canada and Australia are members of the international association. The countries now represented, in addition to the United States, are: Austria, Belgium, Czechoslovakia, Denmark, Finland, France, Germany, Holland, Hungary, Italy, Japan, Norway, Poland, Roumania, Russia, Sweden and Switzerland.

Announcement was also made at the meeting of the reelection of Mr. Serrill as president and Cloyd M. Chapman as vice-president of the Association for the year 1930.

In his annual report to the meeting Mr. Serrill pictured in some detail the work and progress of the Association. Extracts from his report are:

"We have now completed the first year of the activities of our Association since its reorganization at the end of 1928. When the American Engineering Standards Committee became the American Standards Association its methods were made more flexible and its policies more liberal. Its adminstrative set-up was revised, particularly by the creation of the Board of Directors to control the Association's general policies and finances, leaving the technical work in connection with the adoption of standards in the hands of the new Standards Council, formerly the Main Committee.

"It is with great pleasure that I announce at this time one of the most important of the action of the reorganized association. By authority of the Board of Directors, the American Standards Association becomes the eighteenth member of the International Standards Association. . . . .

"Cooperation with the national standardizing organizations of foreign countries is specially important to the United States, because of the tremendous volume of its foreign trade. At the present time American exporters are making extensive use through the A.S.A. of information concerning foreign industrial standards. The greater exchange of such information and other cooperative activities which will follow the affiliation of the A.S.A. with the International Standards Association are certain to prove of great value to American industry.

"Another important event of the past year, aimed to improve the cooperative relations of the Association, was the ratification of an agreement with the U. S. Bureau of Standards, defining the relations to exist between the Bureau and the A.S.A. and specifying the special fields to which each body is to devote itself. Under this agreement commercial standards will be promulgated by the Bureau, particularly for industries which have no organized standardization procedure.

"With the American Home Economics Association and the Laundryowners Association as member bodies, new projects in the field of ultimate consumer goods have been initiated. These projects, which have met with a cordial public reception, reflected in the editorial columns of the daily press, include the establishment of specifications for household refrigerators, sheets and sheeting, and blankets.

"The new projects initiated during 1929 include such subjects as annular ball bearing, methods of laboratory sampling and analyses of coal and coke, standardization of Diesel fuel oils, specifications for coal mine cars and for mine timbering, locomotives for coal mines, graphical symbols used in radio communication and general methods of testing woven textile fabrics.

Ohio Student Branch Float Wins Prize

THE homecoming crowd at Ohio State University on November 23 saw an Illinois football player, in effigy, fed into a threshing machine bearing the sign, "Illini Due for a Threshing." Torn newspapers blown out of the stacker as the separator was drawn along in the homecoming day parade gave a realistic effect and helped it to win first prize as the most original float. The cup which it won graces the library and reading room of the Student Branch of A.S.A.E., which originated and sponsored it.

Personals of A.S.A.E. Members

Arthur Huntington, public relations engineer, Iowa Railway and Light Corp., is author of "Exposing the Joker in the One Cent Electric Rate," originally published as a series of articles in Public Service Magazine and reprinted in bulletin form by the Iowa Committee on Public Utility Information.

C. E. Ramser, drainage engineer, division of agricultural engineering, U. S. Department of Agriculture, is author of U.S.D.A. Technical Bulletin 129, "Flow of Water in Drainage Channels," subtitled "The Results of Experiments to Determine the Roughness Coefficient in Kutter's Formula."

Charles F. Shaw, head of the division of soil technology, University of California, left in January for an extended trip into China where he will be on the staff of the University of Nanking engaged in field work and instruction in soil survey and classification. Next July he will attend the Second International Congress of Soil Science at Moscow, Russia, following which he will study the soils of western Russia and Europe before his return to this country in December.

NEW DEPARTURE BALL BEARINGS

DO-ALL TRACTORS

OIL PULL TRACTORS

A. C. TRACTORS BADGER FEED

CURTIS COMBINES CASE TRACTO

GLEANER-BALDWIN COMBINES

LAUSON TRACTORS FARMALL TRAC

McCORMICK-DEERING THRESHERS

IOWA CREAM SEPARATORS

ADVANCE-RUMELY ENSILAGE CUTTER

CREAMERY PACKAGE PASTEURIZERS

"STEEL 4" HUSKER AND SHREDDER

TRACKSON CRAWLERS

McCORMICK-DEERING ENSILAGE CUT

RED E TRACTORS TWIN CITY TRACTORS BLUE STREAK FEED M

STOVER GAS ENGINES SWEET FEED MIXERS UNITED HAMMER MILLS

BRYANT FEED MILLS CASE COMBINES MINNEAPOLIS COMBINES McCORMICK-DEERING STALK CUTTERS & PULVERIZERS

CATERPILLAR TRACTORS M. B. ENSILAGE CUTTERS MONARCH TRACTORS FULLER & JOHNSON GAS ENGINES ROWELL HAMMER MILLS

BATES TRACTORS UNITED TRACTORS ADVANCE-RUMELY COMBINES

MINNEAPOLIS THRESHERS

JOHN DEERE TRACTORS

GLE TRACTORS E. W. TRACTORS

McCORMICK-DEERING TRACTORS

DVANCE-RUMELY THRESHERS

ROCK ISLAND TRACTORS

RMICK-DEERING CREAM SEPARATORS

E THRESHERS FORDS MILKERS

TWIN CITY COMBINES

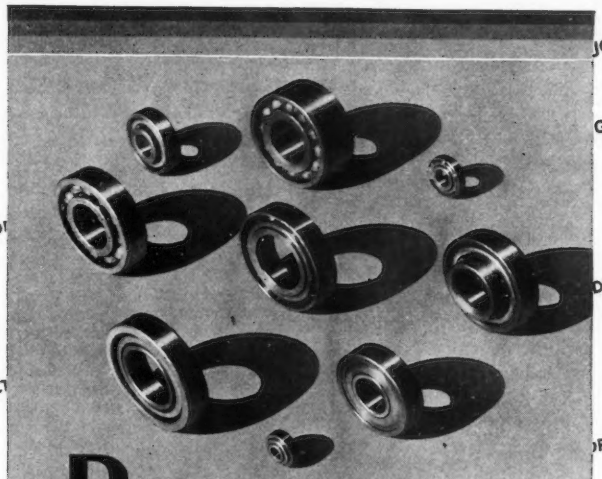
NOMY KING CREAM SEPARATORS

JOHN DEERE COMBINES

CORMICK-DEERING COMBINES

ERY THRESHERS WALLIS TRACTORS

MINNEAPOLIS TRACTORS



PRACTICALLY all power farm implements rely on New Departures for smooth performance, long life and utmost satisfaction in the hands of the user. The New Departure Mfg. Co., Bristol, Connecticut. NOTHING ROLLS LIKE A BALL

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NOTHING ROLLS LIKE A BALL

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the January issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

David A. Bebinger, designer, J. I. Case Co., Rockford, Ill.

Alexander L. Dmitrieff, consulting engineer, Amtorg Trading Corp., 261 Fifth Ave., New York, N. Y.

Raymond R. Drake, junior agricultural engineer, U. S. Department of Agriculture, Hays, Kans.

Orville F. Drennan, designing engineer, Deere & Mansur, Moline, Ill.

Willard J. Durkee, salesman, J. I. Case Co., Trenton, N. J.

Francis D. Fogarty, managing director, Australia Farmers C. D. Harvester Works, Ltd., Melbourne, Australia.

Herbert W. Hayes, agricultural field representative, Friend & Ferry Lbr. Co., Sacramento, Calif.

Henry Morgenthau, Jr., publisher, American Agriculturist, New York, N. Y.

P. A. Rasmussen, research engineer and draftsman, Waukesha Motor Co., Washington, Neb.

Walter E. Selby, special salesman, John Deere Plow Co., York, Neb.

Harry D. Thorn, manager of sales promotion, Chicago Mill & Lumber Corp., Chicago, Ill.

Transfer of Grade

Arthur W. Farrall, research and development engineer, Douthitt Engineering Co., Chicago, Ill. (Associate to Member.)

Harry Miller, instructor in agricultural engineering, Rutgers University, New Brunswick, N. J. (Junior to Associate Member.)

New A.S.A.E. Members

Willard A. Banks, western advertising representative, The Farm Journal, 3233 Cortland Ave., Detroit, Mich.

Eugene R. Bowen, vice-president, Avery Power Machinery Co., Peoria, Ill.

Raymond A. Calvert, plant superintendent. The Frost & Wood Co., Ltd., Smiths Falls, Ont., Can.

Michael B. Fabrikant, professor and scientific investigator, Leningrad Polytechnical Institute, Leningrad, U.S.S.R.

Frederick E. Goetz, research assistant, Kansas State Agricultural College, Manhattan, Kans.

Masami Koga, professor, Kyoto Imperial University, Kyoto, Japan.

George M. Kriegbaum, chief engineer, International Harvester Co., Richmond Works, Richmond, Ind.

Howard Matson, extension architect, Kansas State Agricultural College, Manhattan, Kans.

Lyall H. Mitchell, experimental engineer, General Implement Co., Racine, Wis.

James W. Morse, plant engineer, John Bean Mfg. Co., Lansing, Mich.

Harry L. Pierson, Jr., president, Detroit Harvester Co., Detroit, Mich.

Harper Sibley, part owner and manager, Sibley Farms, Rochester, N. Y.

Howard W. Simpson, engineer, Ford Motor Co., Dearborn, Mich.

John R. Templin, consulting electrical engineer, Templin and Toogood, Consulting Engineers, Christchurch, New Zealand.

S. P. Vostroknutoff, professor of agricultural machinery, Agricultural High School, Kasan, U.S.S.R.

Transfer of Grade

Harold A. Arnold, instructor, University of Tennessee, Knoxville, Tenn. (Junior to Associate Member.)

O. K. Hedden, assistant agricultural engineer, U. S. Department of Agriculture. 615 Front St., Toledo, Ohio. (Junior to Associate Member.)

Employment Bulletin

An employment service is conducted by the American Society of Agricultural Engineers for the special benefit of its members. Only Society members in good standing are privileged to insert notices in the "Men Available" section of this bulletin, and to apply for positions advertised in the "Positions Open" section. Non-members as well as members, seeking men to fill positions, for which members of the Society would be logical candidates, are privileged to insert notices in the "Positions Open" section and to be referred to persons listed in the "Men Available' section. Notices in both the "Men Available" and "Positions Open" sections will be inserted for one month only and will thereafter be discontinued, unless additional insertions are requested. Copy for notices must be received at the headquarters of the Society not later than the 20th of the month preceding date of issue. The form of notice should be such that the initial words indicate the classification. There is no charge for this service.

Men Available

FARM MANAGER, with 15 years' experience in large-scale power farming and livestock operations, desires a position. Has had wide experience in development of both arid and irrigated lands with power machinery and equipment. Also some experience in land drainage. College degree and associate member of American Society of Agricultural Engineers. Salary and share in profits preferred. MA-167.

AGRICULTURAL ENGINEER, formerly director of experimental station and government agricultural and import expert of Kingdom of Yugoslavia, speaking all Slav languages fluently, wants position in agricultural college, commercial farm or dairy plant in research, experimental or extension work; would also like connection in a manufacturer's export department. Russian. Married. Age 31. Willing to go anywhere. MA-168.

AGRICULTURAL ENGINEER, six years power farming experience, graduate of a state university, two years post-graduate experience in research work on farm machinery and teaching experience in university. Will have master's degree in summer 1930. Age 29. Married. Position in corn belt preferred. MA-169.

AGRICULTURAL ENGINEER now employed as a teacher of vocational agriculture desires a position as teacher or research worker in agricultural engineering, preferably at a southern college. Have had two years experience in college teaching and while in present work have had outstanding experience in farm shop work and farm buildings. Age 33. Married. MA-170.

Positions Open

U. S. CIVIL SERVICE OPENINGS

The U. S. Civil Service Commission announces open competitive examinations for associate and assistant engineers in all specialized branches of engineering work, including agricultural engineering. The examination is unassembled. Applicants should secure and execute form 2600, stating the title of the examination and optional subject desired, before March 12, 1930.